TESTING MILK AND ITS PRODUCTS

FARRINGTON AND WOLL

Schuyler Wiedner

E. A. Flansburgh
N. Y. State College of Agr.
Ithaca N. Y.

P117-
136
no.

With Compliments
of E. H. Farrington
to
Schuyler Weidner

Farrington Junior
Tubular Milk and Cream

Composition of milk.

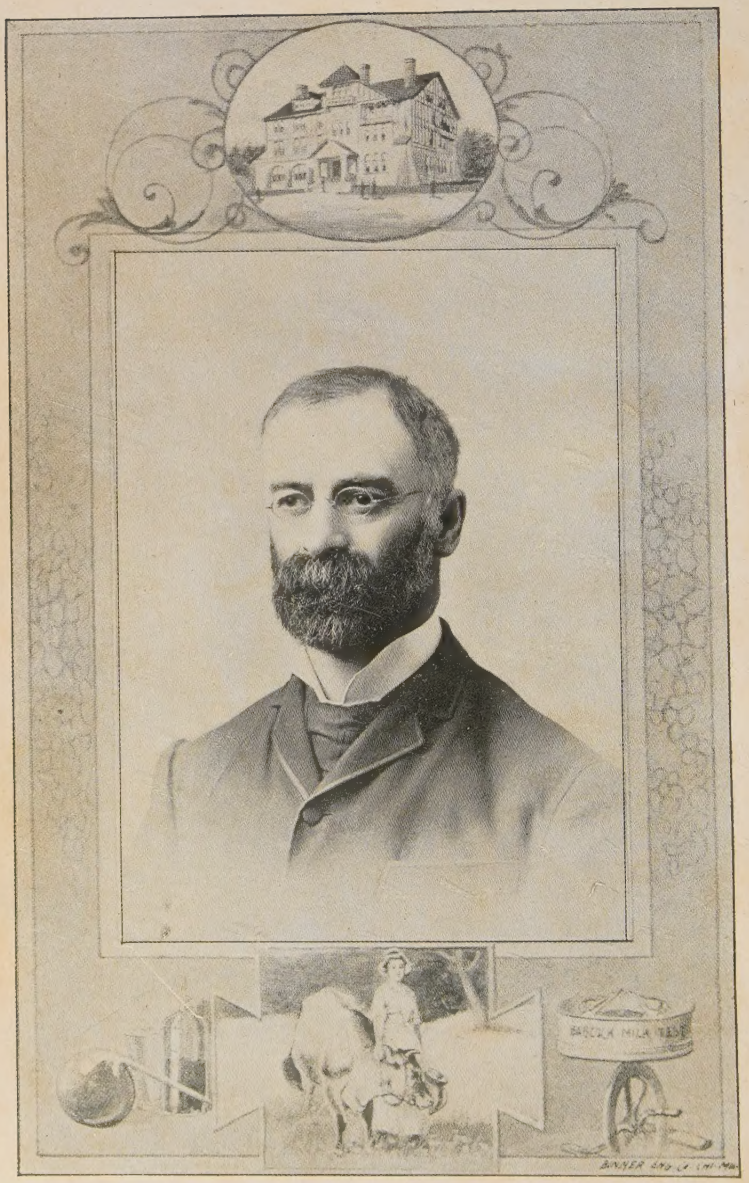
Water	87.0	Page 18
Fat	4.0	
Casein + albumin	3.2	
Milk sugar	5.0	
Ash	.7	

Definition of Milk P.P. 255

" " Cream / Butter / Cheese } P.P. 257

" " Ice Cream / Other products } P.P. 258

Bi-chromate of Potash (.22 m c [illegible] enough [illegible] sample)



DR. S. M. BABCOCK
Inventor of the Babcock Milk Test

TESTING MILK AND ITS PRODUCTS

A MANUAL FOR DAIRY STUDENTS, CREAMERY AND CHEESE FACTORY OPERATORS, FOOD CHEMISTS AND DAIRY FARMERS

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With Illustrations

TWENTY-FIFTH REVISED AND ENLARGED EDITION

MADISON, WIS.
MENDOTA BOOK COMPANY
1918
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BY E. H. FARRINGTON AND F. W. WOLL

CANTWELL PRINTING COMPANY
MADISON, WIS.

PREFACE TO FIRST EDITION.

The present volume is intended for the use of dairy students, factory operators, dairymen, food chemists, and others interested in the testing or analysis of milk and its products. The subject has been largely treated in a popular manner; accuracy and clearness of statement, and systematic arrangement of the subject matter have, however, been constantly kept in mind. The aim has been to make the presentation intelligible to students with no further training than a common-school education, but their work will naturally be greatly lightened by the aid of an able teacher.

Complete directions for making tests of milk and other dairy products are given; difficulties which the beginner may meet with are considered in detail, and suggestions offered for avoiding them. It is expected that a factory operator or practical dairyman, by exercising common sense and ordinary care, can obtain sufficient knowledge of the subject through a study of the various chapters of this book to make tests of milk, cream, etc., even if he has had no previous experience in this line.

For the benefit of advanced dairy students who are somewhat familiar with chemistry and chemical operations, Chapter XIV has been added giving detailed instructions for the complete chemical analysis of milk and other dairy products. The detection of preservatives and of artificial butter or filled cheese has also been treated in this connection.

As the subject of milk testing is intimately connected with the payment for the milk delivered at butter- and cheese factories, and with factory dividends, a chapter has been devoted to a discussion of the various systems of factory book-keeping, and tables greatly facilitating the work of the factory secretary or bookkeeper have been prepared and are included in the *Appendix*.

Madison, Wis., October 1, 1897.

PREFACE TO REVISED EDITION.

Each year that passes brings some valuable contributions to our knowledge of the subjects treated in this book and a frequent revision of it is therefore desirable. The present edition contains descriptions of methods and apparatus that have stood the test of actual use during the past few years; the new information published since the last revision of the book has been carefully sifted, and what was deemed of sufficient importance has been incorporated in such detail as the scope of the book permitted; many changes and additions suggested by the experience of the authors have also been introduced. The book has, in brief, been subjected to a renewed critical examination and careful revision.

The general adoption of the book as a text or reference book in American dairy schools, as well as the favorable reception which it has been accorded by the dairy public in general, will, it is hoped, be further justified by the present revision. Acknowledgment is due to the following parties for loan of electrotypes, viz.: Creamery Pkg. Mfg. Co., Chicago, Ill.; Vermont Farm Machine Co., Bellows Falls, Vt.; D. H. Burrell & Co., Little Falls, N. Y.; Henry Trömner, Philadelphia, Pa.; Torsion Balance Co., New York City, and Marschall Dairy Laboratory, Madison, Wis.

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Testing Milk and Its Products.

INTRODUCTION.

The need of a rapid, accurate and inexpensive method of determining the amount of butter fat in milk and other dairy products became more and more apparent, in this country and abroad, with the progress of the dairy industry, and especially with the growth of the factory system of butter and cheese making during the last few decades. So long as each farmer made his own butter and sold it to private customers or at the village grocery, it was not a matter of much importance to others whether the milk produced by his cows was rich or poor. But as creameries and cheese factories, condensaries and city milk plants multiplied, and farmers in the dairy sections of our country became to a large extent patrons of one or the other of these, a system of equitable payment for the milk or cream delivered became a vital question.

1. Nearly all the creameries in existence in this country up to about 1890 were conducted on the cream-gathering plan: the different patrons creamed their milk by the gravity process, and the cream was hauled to the creamery, usually twice or three times a week, where it was then ripened and churned. The patrons were paid per *inch of cream* furnished. This quantity was supposed to make a pound of butter, but cream

from different sources, or even from the same sources at different times, varies greatly in butter-producing capacity, as will be shown under the subject of cream testing (203[1]). The system of paying for the number of creamery inches delivered could not therefore long give satisfaction.

The proposition to take out a small portion, a pint or half a pint, of the cream furnished by each patron, and determine the amount of butter which these samples would make on being churned in so-called test churns, found but a very limited acceptance, on account of the labor involved and the difficulty of producing a first-class article from all the small batches of butter thus obtained.

2. The introduction of the so-called *oil test churn* in creameries, which followed the creamery-inch system, marked a decided step in advance, and it soon came into general use in gathered-cream factories (202). In this test, glass tubes of about $\frac{5}{8}$ inch internal diameter and nine inches long, are filled with cream to a depth of five inches, and the cream is churned; the tubes are then placed in hot water, and the column of melted butter formed at the top is read off by means of a scale showing the number of pounds of butter per creamery inch corresponding to different depths of melted butter. While the oil test is capable of showing the difference between good and poor cream, it is not sufficiently accurate to make satisfactory distinctions between different grades of good and poor cream.[2] As a result,

[1] Refers to paragraph numbers.
[2] Wis. Expt. Station, bulletin 12 (see also under 203).

full justice cannot be done to different patrons of creameries where payments for cream delivered are made on the basis of this test.

3. The problem of just payment for the milk furnished by different patrons at cheese factories, condensaries and city milk plants is no less perplexing than in the case of gathered-cream factories. By the *pooling system* formerly adopted, each patron received payment in proportion to the number of pounds of milk delivered, irrespective of its quality. Patrons delivering rich milk naturally will not be satisfied with this system when they find that their milk is richer than that of their neighbors. The temptation to fraudulenty increase the amount of milk delivered by watering, or to lower its quality by skimming, will furthermore prove too strong for some patrons; the fact that it was difficult to prove any fraud committed, from lack of a reliable and practical method of milk analysis, rendered this pooling system still more objectionable.

4. Formerly private dairymen and breeders of dairy cattle who desired to ascertain the butter-producing capacities of the individual cows in their herds were obliged to do this by the cumbersome method of trial churnings: by saving the milk of each cow to be tested, for a day or a week, and churning separately the cream obtained. This requires a large amount of work when a number of cows are to be tested, and can not therefore be done except with cows of great excellence or by farmers having plenty of hired help. Here again the need of a practical milk test was strongly felt.

5. Introduction of milk tests. The first method which fulfilled all reasonable demands of a practical and reliable milk and cream test was the Babcock test, invented by Dr. S. M. Babcock, of the Wisconsin agricultural experiment station. A description of the test was first published in July, 1890, as bulletin No. 24 of that Station, entitled: *A new method for the estimation of fat in milk, especially adapted to creameries and cheese factories.* This test, which is now known in all parts of the world where dairying is an important industry, was not, however, the first method proposed for this purpose which could be successfully operated outside of chemical laboratories. It was preceded by a number of different methods, the first one published in this country being Short's method, invented by the late F. G. Short, and described in bulletin No. 16 of Wisconsin experiment station (July 1888).

6. Short's test. In this ingenious method, a certain quantity of milk (20 cc.[1]) was boiled with an alkali solution and afterwards with a mixture of sulfuric and acetic acids; a layer of insoluble fatty acids separated on top of the liquid and was brought into the graduated neck of the test bottles by addition of hot water; the reading gave the per cent. of fat in the sample of milk tested.

Short's method did not find very wide application, both because it was rather lengthy and its manipulations somewhat difficult for non-chemists, and because several other methods were published shortly after it had been given to the public.

7. Other milk tests. Of these may be mentioned, besides the Babcock test already spoken of, the Failyer and Willard method,[2] Parsons' method,[3] Cochran's test,[4] the Patrick or Iowa

[1] See 48, footnote.
[2] Kansas experiment station report, 1888, p. 149.
[3] N. H. experiment station report, 1888, p. 69.
[4] Journal of Anal. Chem., III (1889), p. 381.

station test,[1] and the Beimling (Leffmann and Beam) test.[2] Of foreign methods published at about the same time, or previously, the Lactocrite,[3] Liebermann's method,[4] the Schmid,[5] Thörner,[6] Nahm,[7] Röse-Gottlieb,[8] sin-acid method,[9] and the Gerber sal-method[10] may be noted.

8. All these tests were similar in principle, the solids not fat of the milk being in all cases dissolved by the action of one or more chemicals, and the fat either measured as such in a narrow graduated tube, or brought into solution with ether, gasoline, etc., and a portion thereof weighed on evaporation of the solvent. While this principle is an old one, having been employed in chemical laboratories for generations, its adaptation to practical conditions, and the details as to apparatus and chemicals used were, of course, new and different in each case. The American tests given were adopted to a limited extent within the states in which they originated and even outside of them, as in the case of the Short, Patrick and Beimling methods. The Babcock test, however, soon replaced the different methods mentioned, and during the past twenty-five years it has now been in almost exclusive use in creameries, cheese factories, condensaries, and city milk plants in this country, where payments are made

[1] Ia. exp. sta., bull. No. 8, Feb. 1890; Iowa Homestead, June 14, 1889.
[2] Vermont exp. sta., bull. No. 21, September, 1890. For description of these and other volumetric methods of milk analysis, see Wiley, Agricultural Analysis, Vol. III, p. 490 et seq.; Wing, Milk and its Products, p. 33 et seq., and Snyder, Chemistry of Dairying, pp. 112–113.
[3] Analyst, 1887, p. 6.
[4] Fresenius' Zeitschr., 22, 383.
[5] Ibid., 27, 464.
[6] Chem. Centralbl., 1892, 429.
[7] Milch-Zeitung, 1894, No. 35; 1897, No. 50.
[8] Landw. Vers. Stat., 40, 1.
[9] Milch-Zeitung, 1904, No. 27.
[10] Milch-Zeitung, 1906, No. 8.

on the basis of the quality of the milk delivered, as well as in the routine work in experiment station laboratories, and among milk inspectors and private dairymen.

9. **The Babcock test.** The main cause why the Babcock test has replaced all competitors is doubtless to be sought in its simplicity and its cheapness. It has but few manipulations, is easily learned, and is cheap, both in first cost and as regards running expenses.

The test is furthermore speedy, accurate,[1] and easily applied under practical conditions, and may therefore safely be considered the best milk test available at the present time.

The method is applicable not only to whole milk, but to cream, skim milk, butter milk, whey, condensed milk, and (if a small scale for weighing out the sample is available) to cheese and butter.[2]

With all its advantages, the Babcock milk test is not in every respect an ideal test. The handling of the very corrosive sulfuric acid requires constant care and attention; the speed of the tester, the strength of the acid, the temperature of the milk to be tested, and other points, require constant watching, lest the results obtained be too low or otherwise unsatisfactory. In the hands of careful operators the test can, however, always be relied upon to give most satisfactory results.

10. **Foreign methods.** In European countries several practical milk and cream tests, besides the Bab-

[1] For a summary of comparative analyses made by the Babcock test and gravimetric analysis up to 1892, see Hoard's Dairyman, Oct. 7, 1892, p. 2560; also Schrott-Fiechtl, Milchzeitung, 1896, p. 183 et seq.

[2] The Babcock test, like the ether-extraction method gives, however, somewhat too low results in the case of skim milk and other dairy products low in fat (97).

cock test, are in the use at the present time, viz: *Gerber's acid-butyrometer, the sin-acid* (or *no-acid*) *test, the lactocrite. De Laval's butyrometer, and Fjord's centrifugal cream test.*[1]

Of these tests the last one has never, to our knowledge, been introduced into this country, and the first four only to a limited extent.

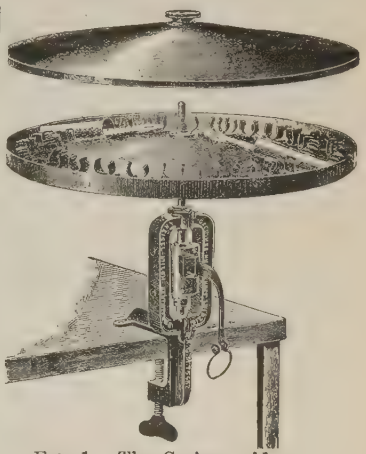


FIG. 1. The Gerber acid-butyrometer.

11. The Gerber method (fig. 1) is essentially the old Beimling method (7), worked out independently by the Swiss chemist, Dr. N. Gerber. In this test sulfuric acid of the same strength as in the Babcock test is used, and a small quantity of amyl alcohol is added. The amyl alcohol facilitates the separation of the fat, but may introduce a source of error on account of impurities contained therein, when the results obtained with a new lot of alcohol can not be checked against gravimetric analysis or against tests made with amyl alcohol known to give correct results. This method is, however, extensively used in European countries, having there practically replaced the Babcock test or been adopted in preference to it.

11a. The sin-acid test was invented by the German chemist A. Sichler and published in 1904.[3] In place of the sulfuric acid used in the Babcock and Gerber tests, Sichler employs a solution of

[1] The *Lister-Babcock* milk test advertised in English papers and known as such in England, is the regular Babcock test, to which the English manufacturers have affixed their name; the same applies to the *Ahlborn-Babcock* and the *Krugmann-Babcock* methods.

[2] Gerber, Die praktische Milchprüfung, 7th edition, 1900.

[3] Milchztg., 1904, p. 417. The word *sin* (*sine*) is Latin and means *without;* hence, when introduced into this country in 1909 the method was called the *no-acid test.*

Rochelle salts, sodium sulfate and sodium hydroxid.[1] 150 cc. of this mixture of salts are dissolved in 1 liter of water. In testing milk, 11 cc. of this solution and 0.6 cc. of "sinol" (isobutylalcohol) are added to 10 cc. of milk. After thorough mixing of the milk and solution the test bottles are placed in water of 113° F. for 3–5 minutes, when they are shaken till all the curd dissolves. They are then revolved in a centrifuge for 3 minutes and the results read off. By heating the bottles for 1 hour in boiling hot water correct results may be obtained without the use of a centrifuge. The main advantages of the method appear to lie in this fact and in that the use of a corrosive acid is avoided.

12. The **Lactocrite** was one of the earliest practical milk tests introduced. It was invented by De Laval in 1886. The acids used in this test are lactic acid (originally, acetic acid) with a mixture of hydrochloric and sulfuric acids. This test is now but rarely met with.

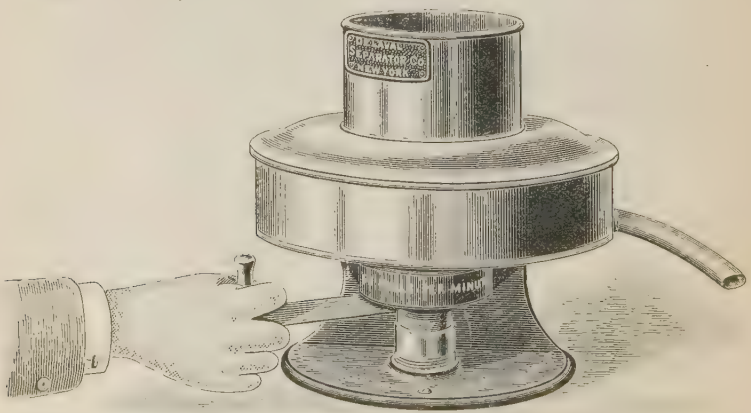


Fig. 2. De Laval's butyrometer.

13. In the **De Laval butyrometer** (fig. 2) the same acid is used as in the Babcock test, but the tubes employed and the manipulations of the method differ materially from this test; a smaller sample of milk is taken (only 2 cc.) and a correspondingly small quantity of acid used. Where a large number of

[1] Barthel-Goodwin, Methods used in Examination of Milk and Dairy Products, p. 77.

milk samples are tested every day, as, for instance, in milk control stations, the butyrometer may be preferable to the Babcock test; but it requires more skill of the operator and does not work satisfactorily in case of sour, loppered, or partially churned milk.

14. **Fjord's centrifugal cream tester**[1] (fig. 3) is extensively used in Denmark and is mentioned in this connection as it furnishes, as a rule, a reliable method for comparing the quality of different lots of milk. The method was published in 1878, by the late N. J. Fjord, director of the state experiment station in Copenhagen, through whose exertions and on whose authority it was introduced into Danish creameries in the middle of the eighties. No chemicals are added in this test, the milk being simply placed in glass tubes, seven inches long and about two-thirds of an inch in diameter, and whirled for twenty minutes at a rate of 2000 revolutions per minute at 55°C (131°F.). The reading of the cream layer thus obtained gives the per cent. of cream, and not of butter fat, in the sample tested. One hundred and ninety-two samples of milk can be tested simultaneously. Within the limits of normal Danish herd milk, the results obtained correspond to the per cents of fat present in the samples, one per cent. of cream being equal to about 0.7 per cent. of fat; outside of these limits the test is, however, unreliable, especially in case of very rich milk and strippers' milk. Only sweet milk can be tested by this method. Milk tests proper, like the Gerber, Babcock and De Laval tests, have during recent years been introduced into Denmark and are used in some creameries.[2]

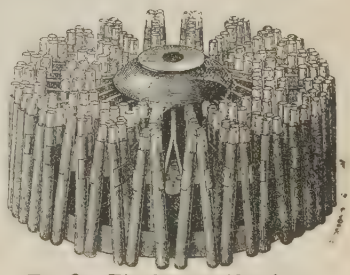


FIG. 3. Fjord's centrifugal cream tester.

[1] State Danish experiment station, Copenhagen, sixth and ninth reports, 1885–7.

[2] Among foreign milk tests in use abroad should also be mentioned the *Lindstrom butyrometer* and the *Wollny refractometer*, both of which, in the hands of trained chemists, may prove better adapted for use where a very large number of samples are to be tested at a time, than any other available milk test.

CHAPTER I.

COMPOSITION OF MILK AND ITS PRODUCTS.

Before taking up the discussion of the Babcock milk test, a brief description of the chemistry of milk and its products is given, so that the student may understand what are the components of dairy products, and the relation of these to each other. Only such points as have a direct bearing upon the subject of milk testing at manufacturing and distributing plants will be treated in this chapter, and the reader is referred to standard works on dairying for more detailed information in regard to the composition of dairy products.

15. Composition of milk. Milk is composed of the following substances: *water, fat, casein, albumen, milk sugar,* and *ash.* A few other substances are present in small quantities, but they are hardly of sufficient practical importance to be considered here. The components of the milk less the water are known collectively as *milk solids* or *total solids,* and the total solids less the fat, i. e., casein, albumen, milk sugar, and ash, are often spoken of as *solids not fat* or the *non-fatty milk solids.* The *milk serum* includes all components of the milk less the fat; the *serum solids* are therefore another name for the solids not fat; when given, they are, however, generally calculated to per cent. of milk serum, not of milk. If, e. g., a sample of milk contains

nine per cent. of solids not fat, and three per cent. of fat, the milk serum will make up 97 per cent. of the milk, and the serum solids, $\frac{9 \times 100}{97} = 9.28$ per cent. of the milk serum.

16. Water. The amount of water contained in cow's milk ranges from 82 to 90 per cent. Normal cow's milk will not, as a rule, contain more than 88 per cent. of water, nor less than 84 per cent. In states where there are laws regulating the sale of milk, as is the case in twenty-two states of the Union (see Appendix, Table II), the maximum limit for water in milk in all instances but one (South Carolina) is 88 per cent.; the state mentioned allows 88.5 per cent. of water in milk offered for sale within her borders. The effect of fraudulently increasing the water content of milk by watering is considered under *Adulteration of Milk* (121).

17. Fat. The fat in milk is not in solution, but suspended as very minute globules, which form an emulsion with the milk serum; the globules are present in immense numbers, viz., on the average about one hundred millions in a single drop of milk; a quart of milk will contain about two thousand billions of fat globules, a number written with thirteen figures. The sizes of the globules in the milk from the same cows vary according to the stage of the period of lactation, the globules being largest at the beginning of the lactation period, and gradually decreasing in size with its progress. Different breeds of cows have fat globules of different average sizes; the Channel Island cows are thus noted for the relatively large fat globules of their

milk, while the lowland breeds, the Ayrshire, and other breeds have uniformly smaller globules. The diameter of average sized fat globules in fresh milkers is about .004 millimeter, or one six-thousandth of an inch; that is, it takes about six thousand such globules placed side by side to cover one inch in length. The globules of any sample of milk vary greatly in size; the largest globules are recovered in the cream when the milk is set or run through a cream separator, and the smallest ones remain in the skim milk; thoroughly skimmed separator skim milk contains only a small number of very minute fat globules.

Milk fat is composed of so-called glycerides of the fatty acids, i. e., compounds of the latter with glycerin; some of the fatty acids are insoluble in water, viz., palmitic, stearic, and oleic acids, while others are soluble and volatile, the chief ones among the latter being butyric, caprylic, and capronic acids. The glycerides of the insoluble fatty acids make up about 92 per cent. of the pure milk fat; about 8 per cent. of the glycerides of volatile fatty acids are therefore found in natural milk- (and butter-) fat. The distinction between natural and artificial butter lies mainly in this point, since artificial butter (butterine, oleomargarine) as well as other solid animal fats contain only a very small quantity of volatile fatty acids. The glycerides of the volatile fatty acids are unstable compounds, and are easily decomposed through the action of bacteria or light; the volatile fatty acids thus set free, principally butyric acid, are the cause of the unpleasant odor met with in rancid butter.

Cow's milk generally contains between three and six per cent. of fat; in American herd milk we find, on the average, toward four per cent. of fat. The milk from single cows in perfect health will occasionally go below or above the limits given, but mixed herd milk rarely falls outside of these limits. The standard adopted by the U. S. government for fat in milk is 3.25 per ct. The legal standard for fat in milk in most states of the Union is 3 per cent.; Rhode Island allows milk containing 2.5 per cent. of fat to be sold as pure, while Georgia and Minnesota require it to contain 3.5 per cent., and Massachusetts 3.7 per cent. (in the months of May and June; see *Appendix,* Table II).

18. Casein and albumen. These belong to the so-called *nitrogenous* substances, distinguished from the other components of the milk by the fact that they contain the element nitrogen. Another name is *albuminoids* or *protein* compounds. Casein is precipitated by rennet in the presence of soluble calcium salts, and by dilute acids and certain chemicals; albumen is not acted upon by these agents, but is coagulated by heat, a temperature of 170° F. being sufficient to effect a perfect coagulation. The casein, fat, and water, are the main components of nearly all kinds of cheese. In the manufacture of cheddar and most other solid cheeses, the casein is coagulated by rennet, and the curd thus formed holds fat and whey mechanically, the latter containing in solution small quantities of non-fatty milk solids. The albumen goes into the whey and is lost for cheese making; in some countries it is also made into cheese by evaporating the whey under constant

stirring; whole milk of cows or goats is often added and incorporated into such cheese (*primost, gjetost*).

Casein is present in milk partly in solution, in the same way as milk sugar, soluble ash-materials and albumen, and partly in suspension, in an extremely fine colloidal condition, mixed or combined with insoluble calcium phosphates. The casein and calcium phosphates in suspension in milk may be retained on a filter made of porous clay (so-called *Chamberland filters*).

About 80 per cent. of the nitrogenous compounds of normal cow's milk are made up of casein; the rest is largely albumen. If the amount of casein in milk be determined by precipitation with rennet or dilute acids, and the albumen by boiling the filtrate from the casein precipitate, it will be found that the sum of these two compounds do not make up the total quantity of nitrogenous constituents in the milk. The small remaining portion (about five per cent. of the total nitrogenous constituents) has been called by various authors, globulin, albumose, hemi-albumose, nuclein, nucleon, proteose, etc. The nitrogenous constituents of milk are very unstable compounds, and their study presents many and great difficulties; as a result we find that no two scientists who have made a special study of these compounds agree as to their properties, aside from those of casein and albumen, or their relation to the nitrogenous substances found elsewhere in the animal body. For our purpose we may, however, consider the nitrogen compounds of milk as made up of casein and albumen, and the term *casein and albumen*, as used in this book, is meant to include the total nitrogenous constituents of

milk, obtained by multiplying the total nitrogen content of the milk by 6.25.[1]

The quantity of casein in normal cow's milk varies from 2 to 4 per cent., and of albumen, from .5 to .8 per cent. The total content of casein and albumen ranges between 2.5 and 4.6 per cent, the average being about 3.2 per cent. Milk with a low fat content will contain more casein and albumen than fat, while the reverse is generally true in case of milk containing more than 3.5 per cent. of fat.

19. Milk sugar or **lactose** belongs to the group of organic compounds known as *carbohydrates.* It is a commercial product manufactured from whey and is obtained in this process as pale white crystals, of less sweet taste and less soluble in water than ordinary sugar (cane sugar, sucrose). About 70 per cent. of the solids in the whey, and 33 per cent. of the milk solids, are composed of milk sugar.

When milk is left standing for some time, viz., from one to several days, according to its cleanliness and the temperature of the surrounding medium, it will turn sour and soon become thick and loppered. This change in the composition and appearance of the milk is brought about through the action of acid-forming bacteria on the milk-sugar. These are present in ordinary milk in immense numbers, and under favorable conditions of temperature multiply rapidly, feeding on

[1] The factor 6.25 is generally used for obtaining the casein and albumen from the total nitrogen in the milk, on the theory that protein compounds contain 16% N.; the factor 6.37 would, however, be more correct, since casein and albumen, according to our best authorities, contain on the average 15.7 per cent of nitrogen ($\frac{100}{15.7}$ =6.37)

the milk sugar as they grow, and decomposing it into lactic acid. When this change alone occurs, there is not necessarily a loss in the nutritive value of the milk, since milk sugar breaks up directly into lactic acid. This is shown by the following chemical formula:

$C_{12}H_{22}O_{11}H_2O$ (*lactose*) $=4$ $C_3H_6O_3$ (*lactic acid*).[1]

Ordinarily the souring of milk is, however, more complicated, and other organic bodies, like butyric acid, alcohol, etc., and gases like carbonic acid are formed, resulting in a loss in the feeding value of the milk. While sour milk may therefore contain a somewhat smaller proportion of food elements than sweet milk, it will generally produce better results when fed to farm animals, especially pigs, than is obtained in feeding similar milk in a sweet condition. The cause of this may lie in the stimulating effect of the lactic acid of sour milk on the appetites of the animals, or in its aiding digestion by increasing the acidity of the stomach juices.

That the souring of milk is due to the activities of bacteria present therein is shown clearly by the fact that sterile milk, i. e., milk in which all germ life has been killed, will remain sweet for any length of time when kept free from infection.

The amount of milk sugar found in normal cow's milk varies from 3.5 to 6 per cent., the average content being about 5 per cent.; in sour milk this content is decreased to toward 4 per cent.

[1] One molecule of milk sugar is composed of 12 atoms of carbon (C), 22 atoms of hydrogen (H), 11 atoms of oxygen (O), and one molecule of water (H_2O). In the same way, the lactic acid molecule consists of 3 atoms of carbon, 6 atoms of hydrogen, and 3 atoms of oxygen.

20. Ash. The ash or mineral substances of milk are largely composed of chlorids and phosphates of sodium, potassium, magnesium and calcium; iron oxid and sulfuric and other acids are also present in small quantities among the normal mineral milk components. The amounts of the different bases and acids found in milk ash have been determined by a number of chemists; the average figures obtained are given in the following table, calculated per 100 parts of milk (containing .75 per cent. of ash) and per 100 parts of milk ash.

Mineral Components of Milk.

	In per cent of milk.	*In per cent of ash*
Potassium oxid (K_2O)	.19 per ct.	25.64 per ct.
Sodium oxid (Na_2O)	.09	12.45
Lime (CaO)	.18	24.58
Magnesia (MgO)	.02	3.09
Iron oxid (Fe_2O_3)	.002	.34
Phosphoric anhydrid (P_2O_5)	.16	21.24
Chlorin (Cl)	.12	16.34
	.762 per ct.	103.68 per ct.
Less oxygen, corresponding to chlorin	.012	3.68
	.75	100.00

The combinations in which the preceding bases and acids are contained in the milk are not known with certainty. According to Söldner, 36 to 56 per cent. of the phosphoric acid found in milk, and from 53 to 72 per cent. of the lime, are present in suspension in the milk as di- and tri-calcium phosphates, and may be separated out by means of Chamberland filters (18), or by long-continued centrifuging (Babcock[1]). The rest of the ash constituents are dissolved in the milk serum.

[1] Wisconsin experiment station report 12, p. 93.

The ash content of normal cow's milk varies but little, as the rule only between .6 and .8 per cent., with an average of .7 per cent. Milk with a high fat content generally contains about .8 per cent. of ash; strippers' milk always has a high ash content, at times even exceeding one per cent. Ordinarily, the mineral constituents are least liable to variations of any of the components of the milk.

21. Other components. Besides the milk constituents enumerated and described in the preceding pages, normal milk contains a number of substances which are present in but small quantities and have only scientific interest, such as the milk gases (carbonic acid, oxygen, nitrogen), citric acid, lecithin, cholesterin, urea, hypoxanthin, lactochrome, etc.

22. Average composition. The average percentage composition of cow's milk will be seen from Table I in the *Appendix*. The following statement shows the limits within which the components of normal American cows' milk are likely to come:

	Minimum.	*Maximum.*	*Average.*
Water	82.0 per ct.	90.0 per ct.	87.4 per ct.
Fat	2.3	7.8	3.7
Casein and albumen	2.5	4.6	3.2
Milk sugar	3.5	6.0	5.0
Ash	.6	.9	.7

23. Colostrum milk. The liquid secreted directly after parturition is known as colostrum milk or biestings. It is a thick, yellowish, viscous liquid; its high contents of albumen and ash are characteristic, and also its low content of milk sugar. Owing to the large quantity of albumen which colostrum contains, it will coagu-

late on being heated toward the boiling point. In the course of three or four days the secretion of the udder gradually changes from colostrum to normal milk; the milk is considered fit for direct consumption or for the manufacture of cheese and butter, when it does not coagulate on boiling and is of normal appearance as regards color, taste, and other properties. For composition of colostrum milk, see *Appendix,* Table I.

24. Composition of milk products. In addition to its use for direct consumption, milk is the raw-material from which cream, butter, cheese, ice cream and condensed milk are obtained.

When milk is left standing for some time or subjected to centrifugal force, it will separate into two distinct parts, *cream* and *skim milk.* The proportion of each part which is obtained, and their chemical composition, will depend on the method by which the separation is effected; in the so-called gravity process where the cream is separated on standing—either in shallow pans in the air, or in deep cans, submerged in cold water—a less complete separation is reached, and the skim milk obtained is richer in fat than when the separation takes place through the action of centrifugal force.

In modern creameries the milk is now always skimmed by means of cream separators. *Separator cream* will contain from 15 to 50 per cent. of fat, according to the adjustment of the separator and of the milk supply; ordinarily it contains about 25 per cent. of fat. Cream of average quality, in addition to the fat content given, consists of about 66 per cent. of water, 3.8 per cent.

casein and albumen, 4.3 per cent. milk sugar, and .5 per cent. ash.

The *skim milk* is made up of the milk serum (15) and a small amount of fat, viz., toward .4 per cent. when obtained by the gravity process, and less than .2 per cent. in the case of separator skim milk. Milk set in shallow pans in the air, or in deep cans in water above 60° F., will give skim milk containing one-half to over one per cent. of fat. Skim milk is used as a food for young farm animals or as human food, and for the manufacture of cheese and casein.

25. Cream is used for the manufacture of *butter* or for direct consumption. In the former case a certain amount of acidity is generally allowed to develop therein previous to the churning process. This secures a more complete churning and produces peculiar flavors in the butter, without which it would seem insipid to most people. Nearly all butter made in this country is salted before being placed on the market Salt is a preservative and for a limited length of time prevents butter from spoiling. Unsalted butter made from sweet cream is a common food article in Southern and Middle Europe, but only an insignificant amount is manufactured and consumed in America; salted butter made in Europe also contains considerably less salt than American butter (see *Appendix,* Table I). Butter contains all the fat of the cream except a small portion which goes into the butter milk, and a small unavoidable mechanical loss incident to the handling of the products. Butter should contain at least 80 per

cent. of fat and ordinarily contains about 83 per cent.; besides this amount of fat, butter is generally composed of about 13 per cent. water, 1 per cent. curd and lactic acid, and 3 per cent. salt.

Butter milk has a composition similar to skim milk, but varies much more than this product, according to the acidity, temperature, and thickness of the cream, and other churning factors. It contains about 9 per cent. of solids, viz., milk sugar (and lactic acid) 4 per cent., casein and albumen 4 per cent., fat .3 per cent., and ash .7 per cent.

26. The quantities of butter and by-products obtained in the manufacture of butter are as follows: 1000 lbs. of milk of average quality will give about 850 lbs. of skim milk and 145 lbs. of cream (separator slime and mechanical loss, 5 lbs.); this amount of cream will make about 42 lbs. of butter and 100 lbs. of butter milk (mechanical loss, 3 lbs.).

27. In the manufacture of *American cheddar cheese,* whole milk is heated to about 86° F., and a small amount of rennet extract is added, which coagulates the casein; the albumen of the milk is not precipitated by rennet and remains in solution (18). "Green" cheese, as taken from the press, is made up, roughly speaking, of 37 per cent. of water, 34 per cent. of fat, 24 per cent. of albuminoids (nearly all casein), and about 5 per cent. of milk sugar, lactic acid, and ash (largely salt). In the curing of cheese there is some loss by drying, but the main changes occur in the breaking up of the firm curd into soluble and digestible nitrogenous compounds, peptones, amids, etc.

Whey is the by-product obtained in the manufacture of cheese. It consists of water and less than 7 per cent. of solids; of the latter about 5 per cent. is milk sugar, .8 per cent. albumen, .6 per cent. ash, and .3 per cent. fat. Whey is generally used for feeding farm animals; it is the raw-material from which milk sugar and whey cheese are made.

28. *Condensed milk* is manufactured from whole milk or from partially skimmed milk. In many brands a large quantity of sugar (25 per cent. or more) is added to the condensed milk in the process of manufacture so as to secure perfect keeping quality in the product. Brands to which no sugar has been added are also on the market, and in case of such brands the relation between the various solid constituents of the condensed milk will be essentially the same as that between the constituents of milk solids. Condensed milk should contain not less than 8% fat, and must be free from preservatives and other foreign substances (except sugar).

Tables are given in the *Appendix* showing the average composition of the various milk products.

Questions.

1. What is the average composition of cow's milk; state briefly the properties of the various constituents.
2. What is meant by total solids; solids not fat; milk serum; serum solids?
3. What is colostrum milk? Give its average composition, and in what particulars it mainly differs from normal milk.
4. Give the average composition of cream, skim milk, butter milk, whey, butter and cheddar cheese.
5. Explain the distribution of the components of milk in (a) butter-making, (b) cheese-making.

CHAPTER II.

SAMPLING MILK.

29. The butter fat in milk is not in solution, like sugar dissolved in water, but the minute fat globules or drops, in which form it occurs, are held in suspension in the milk serum (17). Being lighter than the serum, the fat globules have a tendency to rise to the surface of the milk. If, therefore, a sample of milk is left standing for even a short time, the upper layer will contain more fat than the lower portion. This fact should always be borne in mind when milk is sampled. The rapidity with which fat rises in milk can be easily demonstrated by allowing a quantity of sweet milk to stand in a cylinder or a milk can for a few minutes, and testing separately the top, middle and bottom layer of this milk.

The amount of mixing necessary to evenly distribute the constituents of milk throughout its mass may be ascertained by adding a few drops of cheese color to a quart of milk. The yellow streaks through the milk will be noticed until it has been poured several times from one vessel to another, when the milk will have a uniform pale yellow color. Stirring with a stick or a dipper will not produce an even mixture so quickly or so completely as pouring the milk a few times from one vessel to another. In sampling milk for testing it should always be mixed just before the milk is measured into the bottle; if several tests are made of a sample, the milk should be mixed before each sampling.

30. Partially churned milk. A second difficulty sometimes met with in sampling whole milk arises from the fact that a part of the butter fat may be separated in the form of small butter granules, by too zealous mixing or by reckless shaking in preparing the sample for testing. This will happen most readily in case of milk from fresh cows or of milk containing exceptionally large fat globules. When some of the butter granules are thus churned out, they quickly rise to the surface of the milk after pouring and cannot again be incorporated in the milk by simple mixing; it is, therefore impossible to obtain a fair sample of such milk for testing without taking special precautions which will be explained in the following. The granules of butter may be so small as to pass into the pipette with the milk and the quantity measured thus contain a fair proportion of them, but they will be found sticking to the inside of the pipette when this is emptied, and thus fail to be carried into the test bottle with the milk.

A similar partial churning of the milk will sometimes take place in the transportation cans. When such milk is received at the factory, the butter granules are caught by the strainer cloth through which the milk is poured, and are thus lost both to the factory and to the farmer. This separated fat cannot be added to the cream or to the granular butter, without running the risk of making mottled butter, and it will not enter into the sample of milk taken for testing purposes.

When milk samples are sent by mail or express in small bottles, or carried to the place of testing, they often arrive with lumps of butter floating in the milk or sticking to the glass. This churning of the milk can

be easily prevented by completely filling the bottle or the can. If there is no space left for the milk in which to splash around, the fat will not be churned out in transit.

31. Approximately accurate results may generally be obtained with a partially churned sample of milk, if a teaspoonful of ether be added to it. After adding the ether, cork the bottle and shake it until the lumps of butter are dissolved. This ether solution of the butter will mix with the milk and from the mixture a fairly satisfactory sample may generally be taken. The dilution of milk by the ether introduces an error in the testing, and only the smallest quantity of ether necessary to dissolve the lumps of butter should be used. If desired, a definite quantity of ether, say five per cent. of the volume of the sample of milk to be tested, may be added; in such cases the result of the test must be increased by the per cent. of ether added.

EXAMPLE.—To a 4-oz. sample (120 cc.) of partially churned milk, 5 per cent., or 6 cc. of common ether are added; the mixture gave an average test of 4.2 per cent. The test must be increased by $\frac{5}{100} \times 4.2 = .21$ per cent., and the original milk therefore contained $4.2 + .21 = 4.41$ per cent. of fat.

Milk containing ether must be mixed cautiously with acid in making a test, so as to avoid a loss of the contents of the bottle by the sudden boiling of the ether due to the heat evolved in mixing the milk and the acid.

Instead of adding ether to partially churned samples, the milk may be heated to about 110° F. for a few minutes, so as to melt the butter granules; the sample is now shaken vigorously until a uniform mixture of milk and melted butter is obtained, and a pipetteful is then quickly drawn from the sample.

32. Sampling sour milk. When milk becomes sour, the casein is coagulated and the mechanical condition of the milk thereby changed so as to render difficult a correct sampling. The butter fat is not, however, changed in the process of souring; this has been shown by one of us, among others, in a series of tests which were measured from one sample of sweet milk into six test bottles. A test of the milk in one of these test bottles was made every month for six months, and approximately the same amount of fat was obtained in the tests throughout the series, as was found originally in the milk when tested in a sweet condition.[1] If the milk is in condition to be sampled, souring does not therefore interfere with its being tested by the Babcock test or with the accuracy of the results obtained.

In order to facilitate the sampling of sour or lopped milk, some chemical may be added which will redissolve the coagulated casein and produce a uniform mixture that can be readily measured with a pipette. Any alkali (powdered potash or soda, or liquid ammonia) will produce this effect. Only a very small quantity of powdered alkali is necessary for this purpose. The complete action of the alkali on sour milk requires a little time, and the operator should not try to hasten the solution by adding too much alkali. An excess of alkali will often cause such a violent action of the sulfuric acid on the milk to which the acid is added (on account of the heat generated or the presence of car-

[1] See Hoard's Dairyman, April 8, 1892. The same holds true for cream, as shown by Winton (U. S. Dept. Agr., Div. of Chemistry, bull. 43, p. 112). As to length of time Babcock tests will keep, see Vt exp. sta., bull. 106.

bonates in the alkali) that the mixture will be thrown out of the neck of the test bottle when this is shaken in mixing the milk and the acid (37). When powdered alkali is added to the milk, it should be allowed to stand for a while, with frequent shaking, until the curd is all dissolved and an even translucent liquid is obtained. Such milk may become dark-colored by the action of the alkali, but this color does not interfere with the accuracy of the test.

Instead of powdered soda or potash, these substances dissolved in water (soda or potash lye), or strong ammonia, may be used for the purpose of dissolving the coagulated casein in sour milk. In this case, a definite proportion of alkali solution must be taken, however, 5 per cent. of the volume of milk being usually sufficient, and the results obtained are increased accordingly.

33. Sampling frozen milk. When milk freezes, it separates into two distinct portions: Milk crystals, largely made up of water, with a small admixture of fat and other solids, and a liquid portion, containing nearly all the solids of the milk. In sampling frozen milk it is therefore essential that the liquid and the frozen part be warmed and thoroughly mixed by pouring gently back and forth from one vessel into another; the sample is then taken and the test proceeded with in the ordinary manner (36).

Questions.

1. What precautions must be taken in sampling milk? Give reasons.

2. How can a fair sample be taken of (a) partially churned milk, (b) sour milk, (c) frozen milk?

3. If 15 cc. of ammonia are added to 500 cc. of sour milk, and a test of 3.45 obtained, what is the correct test of the milk?

CHAPTER III.

THE BABCOCK TEST.

34. The Babcock test is based on the fact that strong sulfuric acid will dissolve all non-fatty solid constituents of milk and other dairy products, and thus enable the fat to separate on standing. To effect a speedy and complete separation of the fat, the bottles holding the mixture of milk and acid are placed in a centrifugal machine, a so-called *tester,* and whirled for four minutes; hot water is then added so as to bring the liquid fat into the graduated neck of the test bottles, and after a repeated whirling, the length of the column of fat is read off, showing the per cent. of fat contained in the sample tested.

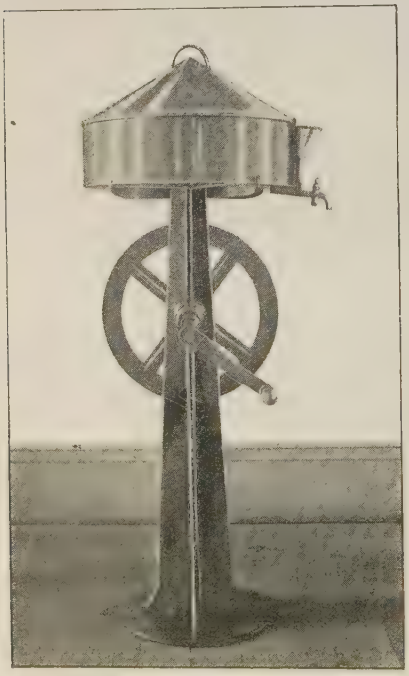


FIG. 4. The first Babcock tester made.

Sulfuric acid is preferable to other mineral acids for the purpose mentioned, on account of its affinity to water; when mixed with milk, the mixture heats greatly, thus keeping the fat liquid without the application of artificial heat and rendering possible a distinct reading of the column of fat brought into the neck of the test bottles.

So far as is known, any kind of milk can be tested by the Babcock test. Breed, period of lactation, quality or age of the milk are of no importance in using this method, so long as a fair sample of milk can be secured. In cases of samples of milk or other dairy products rich in solids it requires a little more effort to obtain a thorough mixture with the acid than with dairy products low in solids, like skim milk or whey, which may be readily mixed with the acid.

A.—Directions for Making the Test.

35. The various steps in the manipulation of the Babcock test are discussed in the following pages; attention is drawn to the difficulties which the beginner and others may encounter in the use of the test, and the necessary precautions to be observed in order to obtain accurate and satisfactory results are explained in detail. The effort has been to treat the subject exhaustively and from a practical point of view, so that persons as yet unfamiliar with the test may turn to the pages of this book for help in difficulties which they may meet with.

36. Sampling. The sample to be tested is first mixed by pouring the milk from one vessel to another two or

three times, so that every portion thereof will contain a uniform amount of butter fat (29). The measuring pipette (fig. 6), which has a capacity of 17.6 cubic centimeters,[1] is filled with the milk immediately after the mixing is completed, by sucking the milk into it until this rises a little above the mark around the stem of the pipette; the forefinger is then quickly placed over the end of the pipette before the milk runs down below the mark. By slightly releasing the pressure of the finger on the end of the pipette, the milk is now allowed to run down until it just reaches the mark on the stem; the quantity of milk contained in the pipette will then, if this is correctly made, be exactly 17.6 cc. The finger should be fairly dry in measuring out the milk so that the delivery of milk may be readily checked by gentle pressure on the upper end of the pipette.

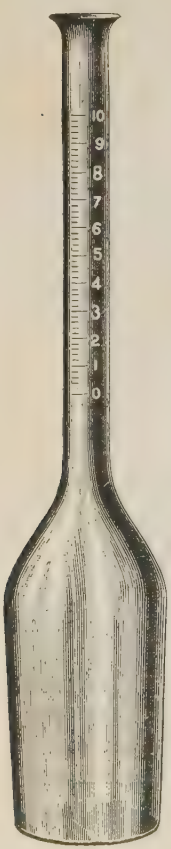


FIG. 5. Babcock milk test bottle.

The point of the pipette is now placed in the neck of a Babcock test bottle (fig. 5),

FIG. 6 17.6 cc. pipette.

[1] See p. 45, foot note.

and the milk is allowed to flow slowly down the inside of the neck. Care must be taken that none of the milk measured out is lost in this transfer. The portion of the milk remaining in the point of the pipette is blown into the test bottle.

The best and safest manner of holding the bottle and the pipette in this transfer is shown in fig. 7. Fig. 8 shows a position which should be avoided, since by holding the bottle in this way, there is danger that some of the milk may completely fill the neck of the bottle, and as a result, flow over the top of the neck.

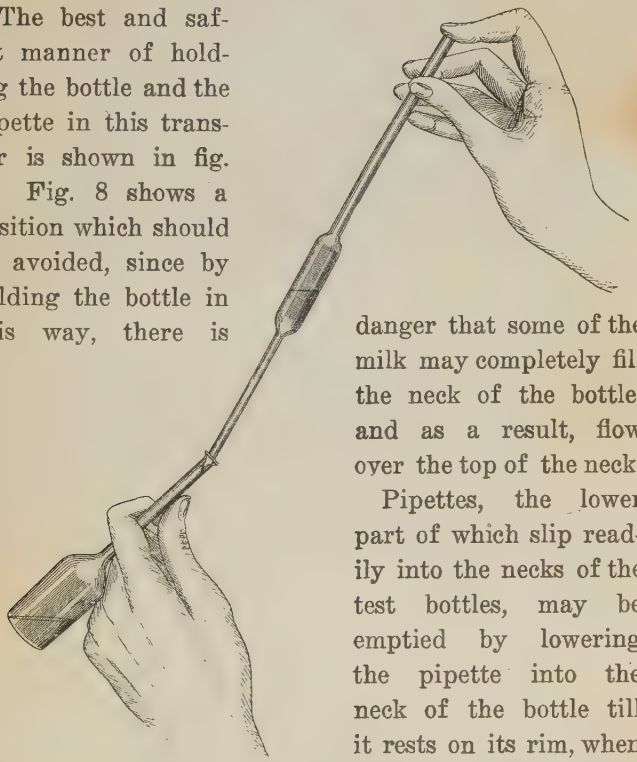


FIG. 7. The right way of emptying pipette into test bottle.

Pipettes, the lower part of which slip readily into the necks of the test bottles, may be emptied by lowering the pipette into the neck of the bottle till it rests on its rim, when the milk is allowed to run into the test bottle.

37. **Adding acid.** The acid cylinder (fig. 9) holding 17.5 cc., is filled to the mark with sulfuric acid of

a specific gravity of 1.82-1.83. This amount of acid is carefully poured into the test bottle containing the milk. In adding the acid, the test bottle is conveniently held at an angle (see fig. 7), so that the acid will run down the wall of the bottle and not run in a small stream into the center of the milk, the bottle being slowly turned around and the neck thus cleared of adhering milk. By pouring the acid into the middle of the test bottle, there is also a danger of completely filling this with acid, in which case the plug of acid formed will be pushed over the edge of the neck by the expansion of the air in the bottle, and may be spilled on the hands of the operator.

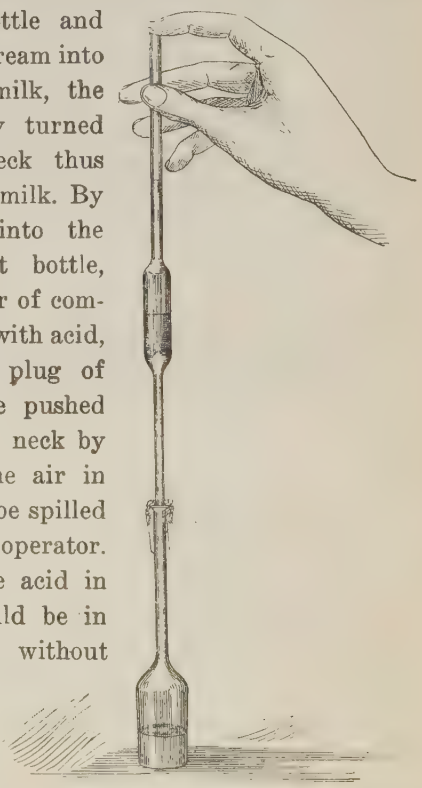


FIG. 8. The wrong way of emptying pipette into test bottle.

The milk and the acid in the test bottle should be in two distinct layers, without much of a black band of partially mixed liquids between them. Such a dark layer is often followed by an indistinct separation of the fat in the final reading. The cause of this may be that a partial mixture of acid and milk before the acid is diluted

with the water of the milk will bring about too strong an action of the acid on this small portion of the milk, and thus char the fat contained therein. The appearance of black flocculent matter in or below the column of fat which generally results, in either case renders a correct measurement difficult and at times even impossible; if the black specks occur in the fat column itself, the readings are apt to be too high; if below it, the difficulty comes in deciding where the column of fat begins.

Fig. 9. 17.5 cc. acid cylinder.

38. Mixing milk and acid. After adding the acid, this is carefully mixed with the milk by giving the test bottle a rotary motion. In doing this, care should be taken that the liquid is not shaken into the neck of the test bottle. When once begun, the mixing should be continued until completed; a partial and interrupted mixing of the liquids will often cause more or less black material to separate with the fat when the test is finished. Clots of curd which separate at first by the action of the acid on the milk, must be entirely dissolved by continued and careful shaking of the bottle. Beginners sometimes fail to mix thoroughly the milk and the acid in the test bottle. As the acid is much heavier than the milk a thin layer of it is apt to be left unnoticed at the bottom of the bottle, unless this is vigorously shaken toward the end of the operation.

The mixture becomes hot by the action of the acid on the water in the milk and turns dark colored, owing to the effect of the strong sulfuric acid on the nitrogenous constituents and the sugar in the milk.

Colostrum milk or milk from fresh cows will form a violet colored mixture with the acid, due to the action of the latter on the albumen present in such milk in considerable quantities (23).

When milk samples are preserved by means of potassium bichromate (190), and so much of this material has been added that the milk has a dark yellow or reddish color, the mixture of milk and acid will turn greenish black, and a complete solution is rendered extremely difficult on account of the toughening effect of the bichromate on the precipitated casein. This difficulty is still more pronounced with milk preserved with formaldehyd.

39. Whirling bottles. After the milk and the acid have been thoroughly mixed, the test bottle is at once placed in the centrifugal machine or tester and whirled for four or five minutes at a speed of 600 to 1200 revolutions per minute, according to the diameter of the tester (66). It is not absolutely necessary to whirl the test bottles in the centrifuge as soon as the milk and the acid are mixed, although this method of procedure is much to be preferred; they may be left in this condition for any reasonable length of time (24 hours, if necessary) without the test being spoiled. If left until the mixture becomes cold, the bottles should, however, be placed in warm water (of about 160° F.) for about fifteen minutes before whirling.

Four minutes at full speed is sufficient for the first whirling of the test bottles in the centrifuge; this will bring all fat to the surface of the liquid in the bottle.

40. Adding water. Hot water is now added by means of a pipette or some special device (10 in fig. 58),[1] until the bottles are filled to near the scale on the neck (80). The bottles are whirled again at full speed for one minute, and hot water added a second time, until the lower part of the column of fat comes within the scale on the neck of the test bottle, preferably to the 1 or 2 per cent. mark, so as to allow for the sinking of the column of fat, due to the gradual cooling of the contents of the bottle. By dropping the water directly on the fat in the second filling, the column of fat will be washed free from light flocculent matter, which might otherwise be entangled therein and render the reading uncertain or too high. A final whirling for one or two minutes completes the separation of the fat.

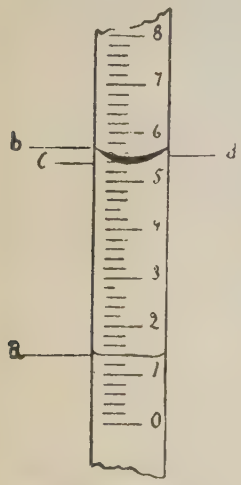


FIG. 10. Measuring the column of fat in a Babcock test bottle.

41. Measuring the fat. The amount of fat in the neck of the bottle is measured by the scale or graduations on the neck. Each division of the scale represents two-tenths of one per cent of fat[2] and the space filled by the fat shows the per cent. of butter fat contained in the sample tested.

The fat is measured from the lower line of separation between the fat and the water, to the top of the fat column, at the point *b*, shown in the figure, the reading being thus taken from *a* to *b*, and not to *c* or to *d*. Comparative

[1] See under 204.

[2] One-tenth of one per cent. in case of 8 per cent. bottles.

gravimetric analyses have shown that the readings obtained in this manner give correct results. While the lower line of the fat column is nearly straight, the upper one is curved, and errors in the reading are therefore easily made, unless the preceding rule is observed.

Results with 8% bottles (44a) agree well with those obtained with the 10% bottles, when care is taken to read the fat column to the extreme top of the meniscus. This appears especially thin in the former bottles and cannot be seen quite as readily as in the 10% bottles.

The fat obtained should form a clear yellowish liquid distinctly separated from the acid solution beneath it. There should be no black or white sediment in or below the column of fat, and no bubbles or foam on its surface. The bottles must be kept warm until the readings are made, so that the column of fat will have a sharply defined upper and lower meniscus. When the testing is done in a cold room, it is a good plan to place the bottles in a pail with water of 140° F. before readings are made. The readings should always be made when the fat has a temperature of about 140° F.; too low results will be obtained if the fat is allowed to cool below 120° F., and too high if readings are taken above 150°. The fat separated in the Babcock test solidifies at about 100° F. If the fat is partly solidified, it is impossible to make an accurate reading.[1]

[1] The effect of differences in the temperature of the fat on the readings obtained will be seen from the following: If 110 and 150° F. be taken as the extreme temperatures at which readings can be made, this difference of 40° F. (22.3° C.) would make a difference in the volume of the fat column obtained in the case of 10 per cent. milk of .00064×2×22.3=.028544 cc., or .14 per cent., .00064 being the expansion coefficient of pure butter fat per degree Centigrade between 50 and 100°

42. Readings of tests of milk made in steam turbine testers with tightly closed covers which prevent the free escape of exhaust steam (71), will come .2 to .3 per cent. too high if the temperature of the fat is allowed to rise to that of the exhaust steam during the process of whirling. In such cases the test bottles must be allowed to cool to about 140°, by placing them in water of this temperature for a few minutes, before readings are taken.[1]

A pair of dividers will be found convenient for measuring the fat, and the liability of error in reading is decreased by their use. The points of the dividers are placed at the upper and lower limits of the fat column (from *a* to *b* in fig. 10). The dividers are now lowered, one point being placed at the zero mark of the scale, and the mark at which the other point touches the scale will show the per cent. of fat in the sample tested. The dividers must be tight in the joint to be of use for this purpose.

B.—Discussion of the Details of the Babcock Test.

43. The main points to be observed as to apparatus and testing materials in order to obtain correct and satisfactory results by this test will now be considered, and such suggestions and help offered as have been found needful from past experience with a great variety of samples of milk, apparatus, and accessories.

C. (*Zune, Analyse des Beurres,* I, 87), and 2, the volume of the fat in cc. contained in 17.6 cc. of 10 per cent. milk. On 5 per cent. milk this extreme difference would therefore be about .07, or nearly .1 of 1%.

[1] See Wis. Expt. Sta. rep., XVII, p. 76.

1.—Glassware.

44. Test bottles. The test bottles should have a capacity of about 50 cc., or less than two ounces; they should be made of well-annealed glass that will stand sudden changes of temperature without breaking, and should be sufficiently heavy to withstand the maximum centrifugal force to which they are likely to be subjected in making tests. This force may, on the average, be not far from 30.65 lbs. (see 66), which is the pressure exerted in whirling the bottles filled with milk and acid in a centrifugal machine of 18 inches diameter at a speed of 800 revolutions per minute.

When 17.6 cc., or 18 grams of milk (48), are measured into the Babcock test bottle, the scale on the neck of the bottles will show directly the per cent. of fat found in the milk. The scale is graduated from 0 to 10 per cent. 10 per cent. of 18 grams is 1.8 grams. As the specific gravity of pure butter fat (i. e., its weight compared with that of an equal volume of pure water) at the temperature at which the readings are made (about 140° F.), is 0.9, then 1.8 grams of fat will occupy a volume of $\frac{1.8}{.9}=2$ cubic centimeters. The space between the 0 and 10 per cent. marks on the necks of the test bottles must therefore hold exactly 2 cubic centimeters. The scale is divided into 10 equal parts, each part representing one per cent., and each of these is again sub-divided into five equal parts. Each one of the latter divisions therefore represents two-tenths of one per cent. of fat when 17.6 cc. of milk is measured out. The small divisions are sufficiently far apart in most Babcock test bottles to make possible the estimation of one-

tenth, or even five-hundredths, of one per cent. of fat in the samples tested.

In the best kinds of Babcock bottles the per cent. marks are complete circles and the half per cent. marks are semi-circles. This greatly aids in making correct readings.

As the necks of Babcock test bottles vary in diameter, each separate bottle must be calibrated by the manufacturers; the length of the scale is not, for the reasons given, apt to be the same in different bottles.

If the figures and lines of the scale become indistinct by use, the black color may be restored by rubbing a soft pencil over the scale, or by the use of a piece of burnt cork after the scale has been rubbed with a little tallow. On wiping the neck with a cloth or a piece of paper the black color will show in the etchings of the glass, making these plainly visible.

Special forms of test bottles used in testing cream and skim milk are described under the heads of cream and skim-milk testing (89, 90, 99).

44a. Eight-per-cent. bottles. Milk test bottles with scale graduated from 0 to 8 per cent. have come into general use of late years, having been adopted in 1911 by the National Dairy Instructors' Association as "standard." The specifications for this bottle and other Babcock glassware are given in par. 307.

45. Marking test bottles. Test bottles can now be bought with a small band or portion of their neck or body ground or "frosted," for numbering the bottles with a lead pencil. Bottles without this ground label can be roughened at any convenient spot by using a wet fine file to roughen the smooth surface of the glass.

There is this objection to the latter method that, unless carefully done, it is apt to weaken the bottles so that they will easily break, and to both methods, that the lead pencil marks made on such ground labels may be effaced during the test if the bottles are not carefully handled. Small strips of tin or copper with a number stamped thereon are sometimes attached as a collar around the necks of the bottles. They are, however, easily lost, especially when the top of the bottle is slightly broken, or at any rate, are soon corroded so that the numbers can only be seen with difficulty.

The best and most permanent label for test bottles is made by scratching a number with a marking diamond on the glass directly above the scale on the neck of the bottles or by grinding a number on the bottle itself. In ordering an outfit, or test bottles alone, the operator may specify that the bottles are to be marked 1 to 24, or as many as are bought, and the dealer may then put the numbers on with a marking diamond.

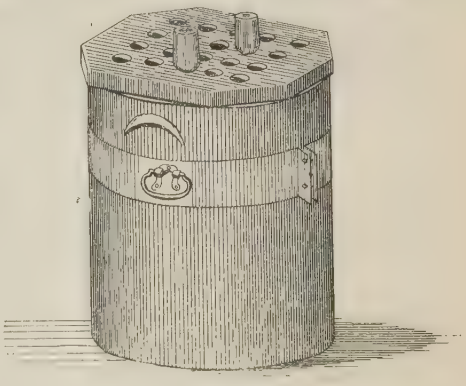


FIG. 12. Waste-acid jar.

A careful record should be kept of the number of the bottle into which each particular sample of milk is measured. Mistakes often happen when the operator

trusts to his memory for locating the different bottles in which tests are made at the same time.

46. Cleaning test bottles. The fat in the neck of the test bottles must be liquid when these are cleaned.

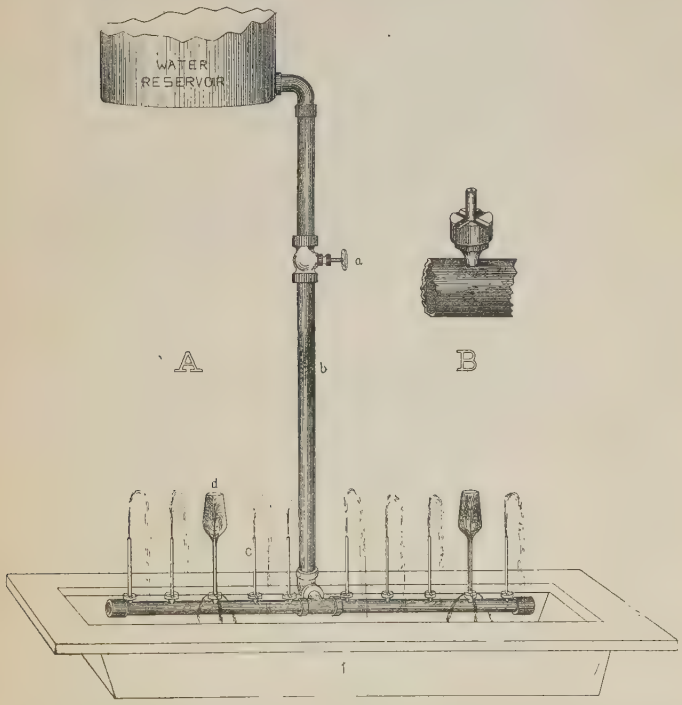


FIG. 13. Apparatus for cleaning test bottles. *A*, apparatus in position; the water flows from the reservoir through the iron pipe *b* into the inverted test bottle *d* through the brass tube *c*, screwed into the iron pipe. *B* shows construction of the rubber support on which the test bottles rest; *f*, sink.

In emptying the acid the bottle should be shaken in order to remove the white residue of sulfate of lime, etc., from the bottom; if the acid is allowed to drain out of the bottle without shaking it, this residue will

be found to stick very tenaciously to the bottom of the bottle in the subsequent cleaning with water.

A convenient method of emptying test bottles is shown in the illustration (fig. 12). After reading the fat column, the bottles are placed neck down, in the half-inch holes of the board cover of a five-gallon stoneware jar. An occasional shaking while the liquid is running from the bottles will rinse off the precipitate of sulfate of lime. A thorough rinsing with boiling hot water is generally sufficient to remove all grease and dirt, as well as acid solution from the inside of the bottles. The apparatus shown in fig. 13 will be found convenient for this purpose. After the bottles have been rinsed a second time, they may be placed in an inverted position to drain, on a galvanized iron rack, as shown in fig. 14, where they are kept until needed. The outside of the bottles should occasionally be wiped clean and dry.

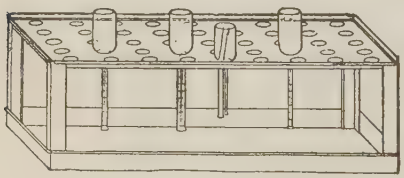


FIG. 14. Draining rack for test bottles.

47. The amount of unseen fat that clings to test bottles used for testing milk or cream, is generally not sufficient to be noticed in testing whole milk, but it plays an important part in testing samples of separator skim milk. It may be readily brought to light by making a blank test with clean water in bottles used for testing ordinary milk, which have been cleaned by simply draining the contents and rinsing once or twice with hot water; at the conclusion of the test the operator will generally find that a few

drops of fat will collect in the neck of the bottles, sometimes enough to condemn a separator.

Boiling hot water will generally clean the grease from glassware for a time, but all test bottles should, in addition, be given an occasional bath in some weak alkali or other grease-dissolving solution. Persons doing considerable milk testing will find it of advantage to provide themselves with a small copper tank, fig. 15, which can be filled with a weak alkali-solution. After having been rinsed with hot water, the test bottles are placed in the hot solution in the tank, where they may be left completely covered with the liquid. If the tank is provided with a small faucet at the bottom, the liquid can be drawn off when the test bottles are wanted. A tablespoonful of some cleaning powder to about two gallons of water will make a very satisfactory solution; *sal soda, Gold Dust, Lewis' lye or Babbitt's potash* are very efficient for this purpose. The cleansing properties of solutions of any of these substances are increased by warming the liquid. The

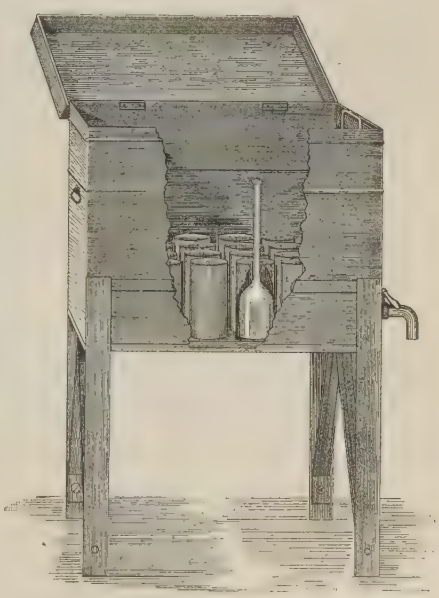
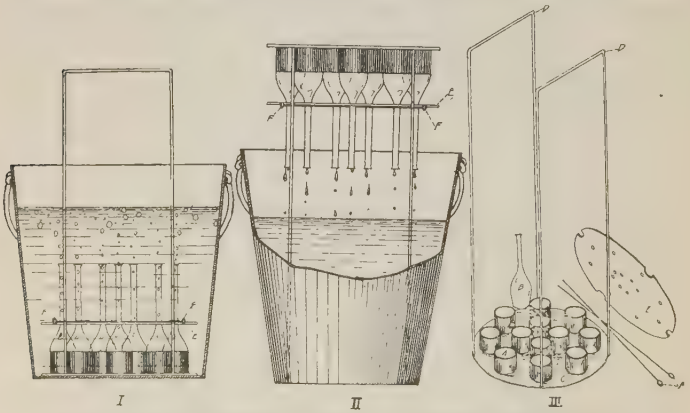


FIG. 15. **Tank for cleaning test bottles.**

test bottles must be rinsed twice with hot water after they are taken from this bath.

An excellent cleaning solution that can be used for a long time, may be made of one-half pound bichromate of potash to one gallon of sulfuric acid.[1]

47a. An arrangement for cleaning a number of test bottles at the same time is shown in fig. 16.[2] III shows



I II III

FIG. 16. A convenient device for cleaning test bottles.

the frame in which the bottles are placed, one in each socket; the metal plate E is put over the necks of the bottles which pass through the holes in it up to the shoulder of the bottles. The pins F, F, are then pushed through holes in the rods D-D, and the plate and bottles thus firmly held in the crate. When secured in this way, the frame full of bottles may be placed in a pail or tank of hot water as in I. They will soon fill with water and the time of filling the bottles one at a time thus saved. When ready to empty the bottles, the

[1] Michels, *Am. Cheesemaker,* Jan. 1903.
[2] Wisconsin experiment station, bull. 129.

frame is reversed and placed in the position shown in II.

One or two rinsings in boiling hot water is usually sufficient to effectually clean the bottles, but when they have been allowed to get greasy they can be dipped into a pail of hot dilute lye; this will saponify the grease and after one or two rinsings in clean hot water the bottles will be bright and clean.

The black stains that sometimes stick to the inside of test bottles after prolonged use, can be removed with a little muriatic acid, or by means of a small stiff brush.

48. Pipette. The difference in the weights of various samples of normal milk generally falls within comparatively narrow limits; if a given volume of water weighs one pound, the same volume of the usual grades of normal milk will weigh from 1.029 to 1.033 pounds, or on the average, 1.03 lbs. 18 grams of water measures 18 cc.[1]; 18 grams of milk will therefore take up a smaller volume than 18 cc., viz., 18 divided by 1.03, which is very nearly 17.5. This is the quantity of milk taken in the Babcock test. A certain amount of milk will adhere to the walls of the pipette when it is emptied, and this thin film has been found to weigh about one-tenth of a gram; consequently 17.6 cc. has been adopted as the capacity of the pipette used for delivering 18 grams of milk.

A B

FIG. 17. Pipette points—A, proper construction; B, undesirable construction.

For convenience in measuring the milk, the shape of the pipette is of importance. The mark on the stem should be two inches or more from the upper end of the pi-

[1] Cubic centimeters (abbreviated: cc.) are the standard used for measuring volume in the metric system, similar to the quart or pint

pette. The lower part should be small enough to fit loosely into the neck of the test bottle, and not contracted to a fine hole at the point; the point should be large enough to allow a quick emptying of the pipette (fig. 17) and not so large that it is difficult to use it. An opening of about 1/8 in. diameter will be found satisfactory.

49. Fool pipettes. Soon after the Babcock test began to be generally used at creameries as a basis of payment for the milk, a creamery supply house put on the market a 20 cc. milk-measuring pipette, which was claimed to show the exact *butter* value of milk, instead of its content of butter *fat*, as is the case in using the ordinary 17.6 cc. pipette. A 20 cc. pipette will deliver 2.4 cc. more milk than a 17.6 cc. pipette, (or 13.6 per cent. more), and the results obtained by using these pipettes will, therefore, be about 13.6 per cent. too high. In considering the subject of *Overrun* (214) it is noted that the excess of butter yield over the amount of fat contained in a certain quantity of milk will range from about 10 to 16 per cent., or on the average. about 12 per cent. 20 cc. pipettes may. therefore, give approximately the yield of butter obtained from a quantity of milk, but as will be seen, this yield is variable, according to the skill of the butter maker and to conditions beyond his control; it cannot therefore be used as a standard in the same manner as the fat content of milk. Similar 22 cc. pipettes were also sent out. These pipettes created a great deal of confusion during the short time they were on the market, and were popularly termed "fool" pipettes. It is not known that such pipettes have been sold of late years.

The dairy laws of many states make it a misdemeanor to use other than 17.6 cc. pipettes for measuring milk where this is paid for by the Babcock test.

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measure in our ordinary system of measures. One quart is equal to a little less than 1,000 cubic centimeters (1 liter). In the same way, grams represent weight, like pounds and ounces. One cc. of water at 4° Centigrade weighs 1 gram; 1,000 grams (=1 kilogram) are equal to 2.2 lbs. Avoirdup. (See *Appendix* for *Comparisons of metric and customary weights and measures.)*

50. Acid measures. A 17.5 cc. glass cylinder (fig. 9) for measuring the acid is generally included in the outfit, when a Babcock tester is bought. This cylinder answers every purpose if only occasional tests are made; the acid is poured into the cylinder from the acid bottle as needed, or a quantity of acid sufficient for the number of test bottles to be whirled at a time, is poured into a small glass beaker provided with a lip, or into a small porcelain pitcher; these may be more easily handled than the heavy acid bottle or jug, and the acid measure is then filled from such a vessel.

Where a considerable number of tests are made regularly, the acid can be measured into the test bottles faster and with less danger of spilling, by using some one of the many devices proposed for this purpose. There is some objection to nearly all of these appliances. automatic pipettes, burettes, etc., although they will often give good satisfaction for a time while new. Sulfuric acid is very corrosive, and operators, as a rule, take but poor care of such apparatus, so that it is a very difficult matter to design a form which will remain in good working order for a long time. Automatic pipettes attached to acid bottles or reservoirs, to prove satisfactory, must be made entirely of glass, and strong, of simple construction, tightly closed and quickly operated.

51. The Combined acid bottle[1] answers these requirements better than any other device known to writers at the present time. Its use is easily understood (see fig. 18); it gives good satisfaction if the hole in the glass stop-cock through which the acid passes has

[1] Formerly sold and known as the *The Swedish Acid Bottle.*

a diameter of at least one-eighth of an inch, as is generally the case. We have used or inspected some half a dozen other devices placed on the market by various dealers for delivering the acid, but cannot recommend them for use in factories or outside of chemical laboratories.

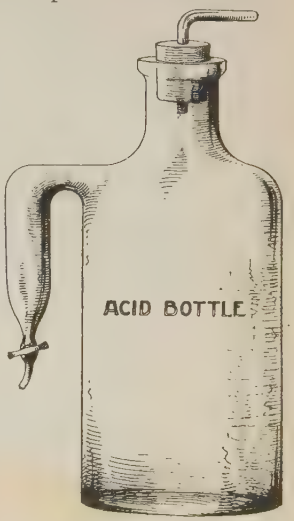

FIG. 18. Acid measuring bottle the side tube is made to hold 17.5 cc. of acid.

52. Instead of measuring out the acid, Bartlett[1] has suggested adding 20 cc. directly to the milk in the test bottles, till the mixture rises to a mark on the body of the bottle at the point where this will hold 37.5 cc., i. e., the total volume of milk and acid (83). This method of adding the acid is in the line of simplicity, but has not become generally adopted. If the method is used, the marks should be put on by the manufacturers, as the operator in attempting to do so will be apt to weaken or break the bottles.

CALIBRATION OF GLASSWARE.

53. Test Bottles. The Babcock 10% milk test bottles are so constructed that the scale of graduation on the neck measures a volume of 2 cubic centimeters, between the zero and the 10 per cent. marks (44). The standards for test bottles and other Babcock glassware adopted by the association of official agricultural chemists of America are given at the close of this book (306). It will be seen that the limit of error for test bottles is one of the smallest graduations on the scale.

[1] Maine experiment station, bull. 31.

or .2 per cent. The correctness of the graduations may be easily ascertained by one of the following methods:

54. (A.) **Calibration with water.** This may be done by means of an accurate pipette or burette, or by weighing the water that the graduated portion of the neck will hold.

a, **Measuring the water.** Fill the test bottle with water to the zero mark on the scale; remove any surplus water and dry the inside of the neck with a piece of filter paper or clean blotting paper; then measure into the bottle 2 cc. of water from an accurate pipette or burette, divided to one-twentieth of a centimeter. If the graduation is correct, 2 cc. will fill the neck exactly to the 10 per cent. mark of the scale.

b, **Weighing the water.** Fill the bottle with water to the zero mark of the scale and remove any surplus water in the neck, as before. Weigh the bottle with the water contained therein. Now fill the neck with water to the 10 per cent. mark, and weigh again. The difference between these weights should be 2 grams.

In all cases where calibrations are to be made, the test bottles, or other glassware to be calibrated, must be thoroughly cleaned beforehand with strong sulfuric acid or soda lye, and washed repeatedly with pure water, and dried. Glassware is not clean unless water will run freely over its surface, without leaving any adhering drops.

55. (B). **The Trowbridge method of calibration.**[1] An extremely simple and accurate method of calibrating test bottles has been proposed by Mr. O. A. Trowbridge of Columbus, Wis. The capacity of the graduated por-

[1] Hoard's Dairyman, March 8, 1901, by DeWitt Goodrich.

tion of the neck of a milk test bottle is measured with a piece of metal which is carefully filed to such a size that it will displace exactly two cubic centimeters of water. He used a thirty-penny wire nail, cutting off the head of the nail and attaching to it a short piece of fine wire. Manufacturers have improved on this rather crude device and standard measures for calibrating test bottles can now be bought of dairy supply houses (see fig. 19).

When a test bottle is to be calibrated by this standard measure, it is filled with water to the zero mark on the neck of the bottle. The water adhering to the neck is carefully removed with a strip of blotting paper, and the measure is then lowered into the test bottle, as shown in the illustration. If the water rises from 0 to 10 on the neck when the upper point of the measure is submerged in the water, the scale is correct. If greater variations than .2 per cent. occur, the bottle should be rejected.

The figure shows one of these calibrators made in two sections, so that the accuracy of the 5 per cent., as well as the 10 per cent. mark on the scale may be ascertained.

FIG. 19. The Trowbridge calibrator.

56. The standard measure. In the place of an iron nail, as originally proposed, a piece of metal or glass rod may be advantageously used as a standard measure. The standardization of this measure is most conveniently

done by weighing. Since the specific gravities of iron, copper, brass, and glass are 7.2, 8.7, 8.5, and about 2.7, respectively, pieces of these materials replacing 2 cc. of a liquid, will weigh 14., 17.4, 17.0 and 5.4 grams, for iron, copper, brass and glass in the order given.

A measure of the right weight may be suspended by a very fine copper or platinum wire (melted into the glass rod if this material be chosen), and is used directly for calibrating test bottles as described above. Before a measure so made is used as a standard, its accuracy should be determined by weighing the amount of water of a temperature of 20° C., which it replaces. The specific gravity of glass especially, varies somewhat according to its composition, so that a standardization of a measure by weight alone cannot be depended upon to always give correct results.

In submerging the measure in the test bottle to be calibrated, care must be taken that all air bubbles are removed before the position of the meniscus of the water is noted; if a metal standard measure is used, it must be kept free from rust or tarnish.

57. (C.) **Calibration with mercury.** 27.10 grams of metallic mercury are weighed into the perfectly clean and dry test bottle. Since the specific gravity of mercury is 13.55, double this quantity will occupy a volume of exactly 2 cubic centimeters (48). The neck of the test bottle is then closed with a small, smooth and soft cork, or a wad of absorbent cotton, cut off square at one end, the stopper being pressed down to the first line of the graduation. The bottle is now inverted so that the mercury will run into its neck. If the total space included between the 0 and 10 marks is just filled by the two cubic centimeters of mercury, the graduation is correct.

The mercury may be conveniently transferred from one test bottle to another, by means of a thin rubber tube which is slipped over the end of the necks of both bottles, and one weigh-

ing of mercury will thus suffice for a number of calibrations. In transferring the mercury, care must be taken that none of it is lost, and that small drops of mercury are not left sticking to the walls of the bottle emptied. A sharp tap on the bottle with a lead pencil will help to remove minute drops of mercury from the inside. Unless the bottles to be calibrated are perfectly clean and dry, it is impossible to transfer all the mercury from one bottle to another.

After several calibrations have been made, the mercury should be weighed again in order to make certain that none has been lost by the various manipulations. Scales similar to those shown under (91) are sufficiently delicate for making these weighings.

58. Test bottles may also be calibrated with mercury by weighing the bottles filled with mercury to the zero mark, and again when filled to the 10 mark. This is the *official* method for testing bottles adopted by the Association of Official Agricultural Chemists (see 306).

59. Cleaning mercury. Even with the best of care, mercury used for calibration of glassware will gradually become dirty, so that it will not flow freely over a clean surface of glass. It may be cleaned from mechanical impurities, dust, grease, water, etc.. by filtration through heavy filter paper. This is folded in the usual way, placed in an ordinary glass funnel and its point perforated with a couple of pin holes. The mercury will pass through in fine streams, leaving the impurities on the filter paper. Mercury may be freed from foreign metals, zinc, lead, etc., sometimes noticed as a grayish, thin film on its surface, by leaving it in contact with common nitric acid for a number of hours; the mercury is best placed in a shallow porcelain or graniteware dish and the nitric acid poured over it, the dish being covered to keep out dust. The acid solution is then carefully poured off and the mercury washed with water; the latter is in turn poured off, and the last traces of water absorbed by means of clean, heavy filter paper.

The mercury to be used for calibration of glassware should be kept in a strong bottle, closed by an ordinary stopper. In handling mercury, care must be taken not to spill any portion of it; finger-rings should be removed when calibrations with mercury are to be made.

Mercury forms the most satisfactory and accurate material for calibration of test bottles, on account of its heavy weight

and the ease with which it may be manipulated. Equally correct results may, however, with proper care be obtained by using water for the calibration.

60. Intermediate divisions. The space between 0 and 10 on the scale of the Babcock test bottle is divided into 50 divisions, each five of which, as previously shown, represent 1 per cent. (44). Since these intermediate divisions are generally made with a dividing machine, they are as a rule correct, but it may happen that they have been inaccurately placed, although the space between 0 and 10 is correct. The accuracy of the intermediate divisions can be ascertained by sliding along the scale a strip of paper upon which has been marked the space occupied by one per cent., and comparing this space with those of each per cent. on the scale.

61. Calibration of skim milk test bottles. The value of each division on the common double-necked skim milk bottles (99) is one-twentieth, or .05 of one per cent.; there are ten of these divisions in the whole scale which, therefore, measures .5 per cent. of fat. It requires very careful work to calibrate this scale and it is best done by weighing the amount of mercury which will just fill the space of .1 cc. between the first and the last divisions (53); the correct weight of this mercury is 1.355 grams.

62. Calibration of cream test bottles. The cream bottles may be calibrated by any of the methods given for milk bottles. The neck of a cream test bottle that measures thirty per cent. fat will hold 6 cc., and 6 grams of water or 81.30 grams of mercury.

The Trowbridge method of calibrating milk test bot-

tles will also be found convenient for cream bottles and the same standard measure used, the part of the scale from 0 to 10 being calibrated first, then that from 10 to 20, 20 to 30, 30 to 40 per cent., etc., in the same way.

63. Pipette and acid cylinder. The pipette and the acid cylinder used in the Babcock test may be calibrated by any of the methods already given. Sufficiently accurate results are obtained by weighing the quantity of water which each of these pieces of apparatus will deliver, viz., 17.5 grams. The necessity of previous thorough cleaning of the glassware is evident from what has been said in the preceding. The pipette and the acid measure may be weighed empty and then again when filled to the mark with pure water, or the measureful of water may be emptied into a small weighed vessel, and this weighed a second time. In either case the weight of the water contained in the pipette or acid measure is obtained by difference.[1]

Calibrations of the acid cylinder are generally not called for, except as a laboratory exercise, since small variations in the amount of acid measured out do not affect the accuracy of the test.

2.—Centrifugal Machines.

64. The capacity of the testing machine to be selected should be governed by the number of tests which are likely to be made at one time. For factory purposes a

[1] One cubic centimeter of distilled water weighs 1 gram, when weighed in a vacuum at the temperature of the maximum density of water (4° C.); for the purpose of calibration of glassware used in the Babcock test, sufficiently accurate results are, however, obtained by weighing the water in the air and at a low room temperature (60° F.)

twenty-four or a thirty-two bottle tester is large enough, and to be preferred to a larger tester, even if a large number of samples are to be tested at a time. The operator can use his time more economically in running a machine of this size than one holding fifty or sixty bottles; the work of filling or cleaning the bottles and measuring the fat can be done while the tester is running if a double supply of bottles is at hand. Large testers require more power than smaller ones, and when sixty tests are made at a time, the fat column in many bottles will get cold, before the operator has time to read them, unless special precautions are taken for keeping the bottles warm.

65. The tester should be securely fastened to a solid foundation and set so that the revolving wheel is level. The latter must be carefully balanced in order that the tester may be run smoothly at full speed. A machine that trembles when in motion is neither satisfactory nor safe, and the results obtained are apt to be too low. High-standing machines are more likely to cause trouble in this respect than low machines, and should therefore be subjected to a severe test before they are accepted.

If all sockets are not filled with bottles when a test is to be made, the bottles must be placed diametrically opposite one another so that the machine will be balanced when run. The bearings should be kept clean and be oiled with as much care as the bearings of a cream separator.

The cover of the machine should always be kept closed while the bottles are whirled, and should not be

removed until the machine stops; it should be tight fitting, since test bottles sometimes break while the machine is running at full speed, and every possible precaution should be taken to protect the operator from any danger from spilled acid or broken glass.

66. Speed required for the complete separation of the fat. There is a definite relation between the diameter of the Babcock testers and the speed required for a perfect separation of the fat. In the preliminary work with the Babcock test the inventor found that with the machine used, the wheel of which had a diameter of eighteen inches, it was necessary to turn the crank so as to give the test bottles seven or eight hundred revolutions per minute, in order to obtain a maximum separation of fat; later work has shown that this speed is ample. Taking the higher figure as a standard, the centrifugal force to which the contents of the test bottles are subjected when supported on an eighteen-inch wheel and turned 800 revolutions per minute, can be calculated as follows:

The centrifugal force, F, acting on the bottles is expressed by the formula

$$F = \frac{w.v.^2}{32.2r} \quad . \quad . \quad . \quad . \quad (1)$$

in which w = the weight of the bottle with contents, in pounds; v = the velocity, in feet per second, and r = the radius of the wheel in feet with the cups in a horizontal position.

When the wheel is turned 800 times a minute, a bottle supported on its rim will travel $2\pi r \times \frac{800}{60} = 2 \times 3.1415 \times \frac{9}{12} \times \frac{800}{600} = 62.83$ feet per second. The weight of a bottle, with milk and acid, is about 3 ounces, or $\frac{3}{16}$ of a pound. Substituting these values for v and w, gives

$$F = \frac{\frac{3}{16} \times 62.83^2}{32.2 \times 1\frac{9}{12}} = 30.65 \text{ lbs.}$$

The bottles are, therefore, under the conditions given, subjected to a pressure of about 30.65 pounds. In order to calculate the speed required for obtaining this force in case of machines of other diameters, the value of v in formula (I) is found from

$$v = \sqrt{\frac{32.2 \, F \times r}{w}} \quad . \quad . \quad (II)$$

Substituting the values for F and w, we have

$$v = \sqrt{\frac{32.2 \times 30.65 \, r}{\frac{3}{16}}} = \sqrt{5264 \, r}$$

In this equation the values $r = 5, 6, 7, 8, 9, 10, 11, 12$ inches are substituted in each case ($1\frac{5}{12}$, $1\frac{6}{12}$, $1\frac{7}{12}$, . . $1\frac{23}{12}$), and the velocity in feet per second then found at which the bottles are whirled when placed in wheels of diameters 10 to 24 inches, and subjected in each case to a centrifugal force of 30.65 lbs. As the number of revolutions per minute $= \frac{60v}{2\pi r}$, v being as before the velocity in feet per second, and r the radius of the wheel; the speed at which the wheel must be turned is found by substituting for v the values obtained in the preceding calculations in case of wheels of different diameters. The results of these calculations are given in the following table:

Diameter of wheel, D.	*Velocity in feet per second, v.*	*Number of revolutions of wheel per minute.*
10	46.84	1074
12	51.31	980
14	55.43	909
16	59.26	848
18	62.84	800
20	66.24	759
22	69.47	724
24	72.56	693

These figures show that a tester, e. g., 24 inches in diameter, will require less than 700 revolutions per minuate for a perfect separation of the fat in Babcock bottles, while a ten-inch tester must have a speed of nearly 1100 revolutions in order to obtain the same result.

The speed at which testers of different diameters should be run to effect a complete separation has been calculated by Prof. C. L. Beach in the following manner.[1] The same standard as before is taken, viz., 800 revolutions for an 18-inch tester (radius 9 inches); then if x designate the radius of the tester and y the speed required, we have

$$xy^2 = 9 \times 800^2, \text{ or}$$

$$y = \sqrt{\frac{9 \times 800^2}{x}}$$

The figures obtained by the use of this formula are similar to those given in the preceding table.

67. To find the number of turns of the handle corresponding to the number of revolutions made by the wheel, the handle is given one full turn, and the number of times the wheel revolves, is noted. If the wheel has a diameter of 20 inches and revolves 12 times for one turn of the handle, the latter should be turned $\frac{759}{12} = 63$ times a minute (see table), or about once every second, in order to effect a maximum separation of fat. By counting the number of revolutions, watch in hand, and consulting the preceding table, the operator will soon know the speed which must be maintained in case of his particular machine. It is vitally important that the required speed be always kept up; if through carelessness, worn-out or dry bearings, low steam pressure, etc., the speed is slackened, the results obtained will be too low; it may be a few tenths, or even more than one per cent. Care as to this point is so much the more essential, as the results obtained by too slow whirling may seem to be all right, a clear separation of fat and

[1] Private communication.

good duplicates being often obtained, even when the fat is not completely separated.

68. Ascertaining the necessary speed of testers. In buying a tester the operator should first of all satisfy himself at what speed the machine must be run to give correct results; the preceding table will serve as a guide on this point. He should measure out a dozen tests of the same sample of milk, and whirl half the number at the speed required for machines of the diameter of his tester. Whirl the other half at a somewhat higher speed. If the averages of the two sets of determinations are the same, within the probable error of the test (say, less than one-tenth of one per cent.), the first whirling was sufficient, as it is believed will generally be the case. If the second set of determinations come higher than the first set, the first whirling was too slow, and a new series of tests of the same sample of milk should be made to ascertain that the speed in the second set of determinations was sufficient.

This method will test not only the speed required with the particular machine at hand, but will also serve to indicate the correctness of the calibration of the bottles. A large number of tests of the same sample of milk made as directed (pouring the milk once or twice previously to taking out a pipetteful for each test) should not vary more than two-tenths of one per cent. at the outside, and in the hands of a skilled operator will generally come within one-tenth of one per cent. If greater discrepancies occur, the test bottles giving too high or too low results should be further examined, and calibrated according to the directions already given (53 *et seq.*).

69. Hand testers. When only a few tests are made at a time, and at irregular intervals, as in case of dairymen who test single cows in their herds, a small hand tester answers every purpose. These may be had in sizes from two to twelve bottles. In selecting a particular make of tester the dairyman has the choice of a large number of different machines. Most of the first machines placed on the market for this purpose were so cheaply and poorly constructed as to prove very unsatisfactory after having been in use for a time. The competition between manufacturers of dairy supplies and the demand of dairymen for something cheap, fully account for this condition of affairs. This applies especially to the early machines made with belts or friction application of power. Hand testers made with cog-geared wheels can be depended on to give the necessary speed when run according to the manufacturers' directions; the earlier machines of this kind were very noisy, but at the present time the best machines on the market are of this type. These are provided with spiral cog-gearing and ball bearings, are strongly made and will run smoothly and with little noise (figs

FIG. 20. Type of Babcock hand testers.

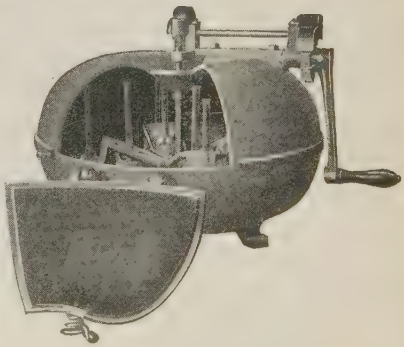

FIG. 21. Type of Babcock hand testers.

20 and 21); in cog-geared machines the bottles are always whirled at the speed which the number of turns made by the crank would indicate.

70. Power testers. For factory purposes, steam turbine machines (figs. 22-24) are most satisfactory when well made and well cared for. They should be provided with a speed indicator and steam gauge, both for the purpose of knowing that sufficient speed is attained, and to prevent what may be serious accidents from a general smash-up, if the turbine "runs wild" by turning on too much steam. The revolving wheel of the tester should be made of wrought or malleable iron, or of wire, so that it will not be broken by the centrifugal force and cause accidents. The swinging pockets which hold the test bottles in most machines should be so made that the bottles will not strike the center of the revolving frame when in a horizontal position. Tests have often been lost by the end of the neck catching at the center, the bottles thus failing to take an upright position when the whirling stops.

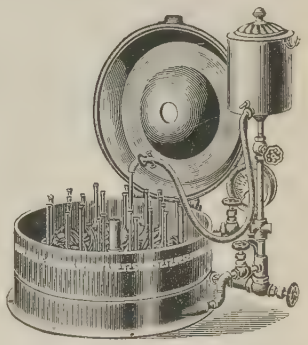

FIG. 22. Type of Babcock steam turbine testers.

71. The exhaust steam pipe of turbine testers should not have too many turns or be much reduced in size from that of the opening in the tester. A free escape of the exhaust steam is necessary to prevent the steam from collecting in the test bottle chamber and overheating the test bottles when whirled (41).

The covers of some testers have an opening provided with a sliding damper or some arrangement by which it can be closed when desired. If whole milk or cream is being tested, this hole should be open so that a draft of air may enter the chamber during the whirling and force the steam into the exhaust pipe. If skim milk is being tested, the opening in the cover should be closed. This shuts off the draft of air, and the exhaust steam heats the test bottles during whirling to 200 degrees F. in some cases. This high temperature aids in separating the fat in skim milk and gives fairly correct tests of samples containing less than one-tenth per cent fat (98). Some turbine testers are provided with holes in the covers and a thermometer is placed in the cover.

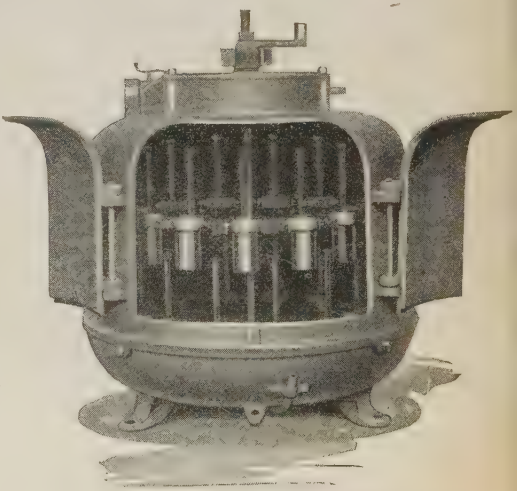

FIG. 23. Type of Babcock steam turbine testers.

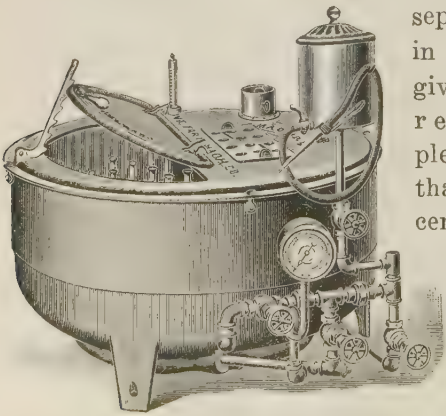

FIG. 24. **Type of Babcock turbine testers** (for testing cream in 9-in. cream bottles).

Babcock testers run by electricity have lately been put on the market by several manufacturers (fig. 25). Where no steam, but electrical current is available, these machines may be installed to great advantage, as they are convenient to use and may be depended on to run at the required speed. Some provision for getting hot water must be at hand in using electrical Babcock testers.[1]

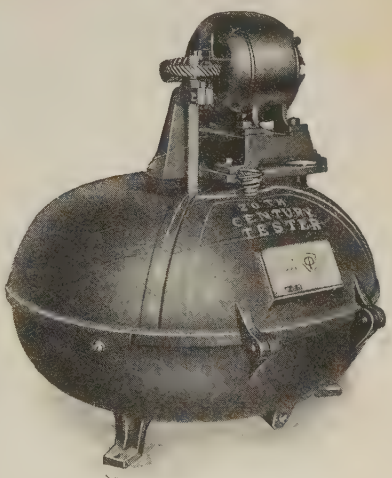

FIG. 25. Type of Babcock electrical testers.

3.—SULFURIC ACID.

72. The sulfuric acid to be used in the Babcock test should have a specific gravity of 1.82-1.83.[2] Commercial sulfuric acid (sometimes called *oil of vitriol*) is always used; it can be bought for about 2 cents a pound in carboy lots and 25 cents or less a quart at retail. One quart of acid is sufficient for fifty tests. The acid should be kept in glass bottles or jugs, preferably glass or rubber stoppered ones, since a cork stop-

[1] The method of installation of a 40-bottle electrical Babcock tester is described in detail in Rept. Dept. of Health, City of Chicago, 1906, p. 18.

[2] A specific gravity of 1.82 means that a given volume of the acid weighs 1.82 times as much as the same volume of water at the same temperature (see also under *Lactometer*, 109).

per is soon dissolved by the acid and rendered useless. If the bottle is left uncorked, the acid will absorb moisture from the air and after a time will become too weak for use in this test.

Lead is the only common metal which is not dissolved by strong sulfuric acid; where considerable milk testing is done, it is therefore desirable to provide a small table or tray covered with sheet lead on which the acid may be handled. The acid dissolves iron, tin, wood and cloth, and burns the skin. If acid is accidentally spilled, plenty of water should be used at once to wash it off. Ashes, potash, soda, and ammonia neutralize the action of the acid, and a weak solution of any one of these alkalies should be used after the acid has been washed off with water. The red color caused by the action of weak acid on clothing can be removed by wetting the spot with dilute ammonia; this must, however, be applied while the stain is fresh, and is in its turn washed off with water.

73. Testing the strength of acid. The strength of the acid can be easily tested by the use of a balance like that shown in fig. 34 (91). A *dry* test bottle is weighed and then filled with acid exactly to the zero mark, or to any other particular line of the scale. It is then again weighed accurately; the difference between the two weights will give the weight of the acid in the bottle. The bottle is then emptied and thoroughly rinsed with water (until the water has no longer an acid taste); it is then filled with pure water to the same line as before and weighed; the difference between this weight and that of the empty bottle gives the weight

of the same volume of water as that of the acid weighed. The specific gravity of the acid is obtained by dividing the weight of the acid by the weight of the water. If the quotient comes between 1.82 and 1.83 the acid is of correct strength. The outside of the test bottle should always be wiped dry before the liquids are weighed. Unless great care is taken in measuring the acid and the water, and in weighing both these and the test bottle, the results obtained will not be trustworthy.

74. Acid that is a little *too strong* can be used by taking less than the required amount for each test, e. g., about 15 cc. Operators are warned against reducing the strength of the acid by adding water to it, as accidents may easily occur when this is done. A too strong acid can, if desired, be weakened by simply leaving the bottle uncorked for a time, or by pouring the acid into a bottle containing a small quantity of water. In the latter case the first portions of acid should be added carefully, a little at a time, shaking the bottle after each addition, so as not to cause it to break on account of the heat evolved in mixing the acid and the water. *Never dilute sulfuric acid by pouring water into it.*

A helpful suggestion for using acid that is too strong or would give a charred fat on account of high temperature of acid or milk, or both, has been made by M. L. Holm, Assistant Chemist Chicago Dept. of Health, viz., to add 2 cc. of 80 per cent. glycerin (80 parts of commercial glycerin and 20 parts of water, by volume) to the milk sample, prior to adding the acid.[1] The gly-

[1] American Food Journal, 1907, No. 7, p. 28; Hoard's Dairyman, Nov. 8, 1907.

cerin protects the milk to some extent from the acid before the two are mixed, and a clear fat may thus often be secured under otherwise unfavorable conditions. The results appear not to be influenced by the addition of the glycerin.

75. If the acid is a little *too weak*, correct results may be obtained by using more than the specified quantity, say 20 cc. If a good test is not obtained with this quantity of acid, a new lot must be secured, as its specific gravity in such a case is below 1.82. The observing operator will soon be able to judge of the strength of the acid by its action on milk in mixing the two liquids in the Babcock test bottles; it is indeed remarkable what slight differences in the specific gravity of the acid will make themselves apparent in working the test, as regards the rapidity with which both the curdled milk is dissolved and the mixture of acid and milk turns black.

76. Strength of sulfuric acid. The relation between the strength of sulfuric acid and its specific gravity will be seen from the following table:

Specific Gravity of Sulfuric Acid of Different Strength.

Specific Gravity (15°C., water 4°C.).	*Sulfuric Acid (H_2SO_4)*
1.841	97 per cent.
1.840	96 "
1.839	95 "
1.837	94 "
1.834	93 "
1.830	92 "
1.825	91 "
1.820	90 "
1.815	89 "
1.808	88 "

It will be noticed that the sulfuric acid to be used in the Babcock test should contain 90 to 92 per cent. of acid (H_2SO_4); slightly weaker or stronger acid than this may, as previously stated, be used by varying the quantity of acid taken for each test according to the strength of the acid, but successful tests cannot, as a rule be made with acid weaker than 89 per cent. or stronger than 95 per cent.

77. **The Swedish acid tester** is a small hydrometer, intended to show whether the acid used in the Babcock test is of the correct strength. An examination of these testers will show that they are practically useless for the purpose intended, from the fact that they are not sufficiently sensitive; while the testers examined were found to sink to the line marked *Correct* on the scale, when lowered into sulfuric acid of a specific gravity of 1.83, they would sink to a point much nearer the same mark, than to the lines marked *Too strong* or *Too weak,* respectively, when lowered into either too strong or too weak acid.

78. **The color of the fat column an index to the strength of the acid used.** The strength of the acid is indicated to a certain extent by the color of the fat which separates in the neck of the test bottle when milk is tested. If the directions given for making the tests are carefully followed, the fat separated out will be of a golden yellow color. If the fat is light colored or whitish, it generally indicates that the acid is too weak, and a dark colored fat, with a layer of black material beneath it, shows that the acid is too strong, provided the temperature of both milk and acid is about 70°. [For influence of temperature, see next paragraph.] The acid used in the test is not of sufficient strength to appreciably attack the fat at ordinary temperatures of testing, but a variation in the strength of the acid

or in the temperature of the milk influences the intensity of the action of the acid on the fat, as indicated by the color of the fat obtained.

79. Influence of temperature on the separation of fat. The intensity of the action of the sulfuric acid on the milk is influenced by the temperature of either liquid; the higher the temperature, the more intense will be the action of the acid on the solids of the milk.

The following experiment shows the relation between the strength of the acid, the temperature of the milk and the color of the fat:

First:—From a sample of milk measure the usual quantity for testing into each of three bottles, A, B and C. Place A in *iced* water, and C in *warm* water, leaving bottle B at *ordinary* temperature. After the bottles have been left for ten minutes under these conditions, add the normal quantity of acid to each and proceed with the test in the ordinary manner.

Second:—Measure some of the same milk into three other bottles, D, E and F. Into test bottle D pour the usual amount of rather weak acid; add the same amount of acid of normal strength (1.82-1.83) to bottle E, and add 17.5 cc. of a still stronger acid (concentrated sulfuric acid, sp. gr. 1.84), in test bottle F; complete the tests in the usual way.

On the completion of the preceding six tests the operator will notice that the fat in the necks of test bottles A (*cold milk*) and D (*weak acid*) is much lighter colored than that in C (*warm milk*) and F (*strong acid*), and that the color of the fat in B (*normal temperature*) and E (*normal acid*) is somewhere between that of these two series.

It may be noticed that acid from the same carboy will act differently on milk in summer than in winter time, if the acid and the milk are not brought to a temperature of about 70° before testing during both seasons. The temperature of the liquids may be as low as 40° F. in winter and as high as 80° F. in summer. This dif-

ference of forty degrees will often have considerable influence on the clearness of the fat separated, showing white curdy substances and a light colored fat in winter, or black flocculent specks, with a dark colored column of fat in summer. Both these defects can be avoided, when the acid is of the proper strength, by bringing the temperature of the milk and the acid to about 70° F. before the milk is tested.

The operator should be particularly cautious against over-heating either milk or acid, since the heat intensifies the action of the acid and this may become so violent as to force the hot liquid out of the neck of the test bottle when the acid is added to the milk, thus spoiling the test and possibly causing an accident.

4.—Water to be used in the Babcock Test.

80. Pure rain water, condensed steam, or soft water should be used for the purpose of bringing the fat into the neck of the test bottles. The surface of the fat column will then usually be clear and distinct. The foam or bubbles that sometimes obscure the upper line (meniscus) of the fat, making indistinct the point from which to measure it, is generally caused by the action of the acid on the carbonates in hard water. The carbonic acid gas liberated from such water by the sulfuric acid is held more or less by the viscid fat and produces a layer of foam on its surface. If clean soft water cannot be obtained for this purpose, hard water may be used, by adding a few drops of sulfuric acid to the water before it is heated, thus causing the carbonic acid to be ex-

pelled. By simply boiling, many hard waters will be rendered soft and adapted to use in the Babcock test, as most of the carbonates which cause this foaming are thereby precipitated.

If the test has been completed, and a layer of foam appears over the fat, it may be destroyed by adding a drop or two of alcohol. If this is done, the fat column should be read at once after the alcohol is added, as the latter will soon unite with the fat and increase its volume. (See also 96 on the use of glymol in cream testing.)

81. Reservoir for water. When only a few tests are made at one time, hot water can be added with the 17.6 cc. pipette. If many tests are made, the water may be conveniently and quickly filled into the test bottles by drawing it from a small copper reservoir or tin pail suspended over the testing machine.[1] The flow of water through a rubber tube connected with the reservoir, is regulated by means of a pinch cock. The water must be hot when added to the test bottles so as to keep the fat in a melted condition until the readings are taken. Most turbine testers are now made with a very convenient water reservoir attached to the tester (figs. 22-24).

The use of zinc or steel oilers, or perfection oil cans has been suggested as a convenient method of adding hot water to the test bottles, but most operators prefer to add water to the bottles by means of a piece of rubber tubing connected with a reservoir, as shown in the illustrations just referred to.

[1] Ordinary tinware will soon rust with water standing in it, and copper reservoirs are therefore more economical.

5.—Modifications of the Babcock Test.

83. Bartlett's modification. Bartlett[1] proposed a modification of the method of procedure in the Babcock test, which aims to simplify the manipulations. 20 cc. of acid are added, instead of 17.5 cc., and the bottles filled with the milk-acid mixture are left standing for not less than five minutes and then filled with hot water to within the scale; the bottles are then whirled for five minutes at the regular rate (52).

83a. Siegfeld's modification. The German dairy chemist Siegfeld in 1899 proposed a modification of the Babcock test,[2] using 2 cc. of amyl alcohol with the sulfuric acid, and filling up with dilute sulfuric acid (1:1, sp. gr., 1.5) in one filling, in place of water after the whirling. A clear separation of the fat is facilitated by both these changes, but when properly conducted, there is no difficulty whatever in obtaining a clear fat column in the Babcock test as described in this book, and the modification has not therefore been generally introduced in American factories. It has, however, been adopted in many German creameries where the Babcock test is used.

84. Bausch and Lomb centrifuge. Fig. 29 shows a form of hand centrifuge which may be used to advantage by physicians or in pathological laboratories for the determination of fat in milk. The centrifuge is especially designed for examination of urine, sputum, blood, etc., but has been adapted to milk analysis by the Leffmann & Beam test, a special form of bottle (fig. 30) having been constructed for this purpose. The machine gives satisfactory results by the Babcock test as well, provided the acid used is 1.83-1.84, or if the bottles containing the acid-milk mixture be placed in hot water for five or ten minutes prior to the whirling. As the

[1] Maine experiment station, bull. 31 (s. s.)
[2] *Molkerei Ztg.*, 1899, p. 51.

bottles are calibrated for only 5 cc. of milk and the neck of the bottles, with scale, is correspondingly fine, testing milk with this machine requires some nicety of manipulation not called for in case of regular Babcok testers constructed for the use of factory operators and dairymen.

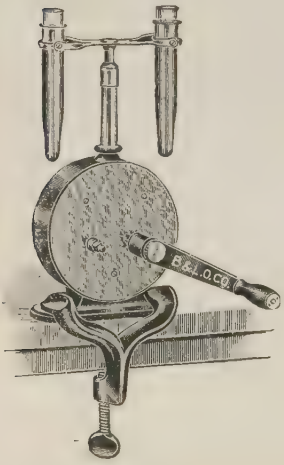

Fig. 29. Physician's centrifuge that may be used for milk testing.

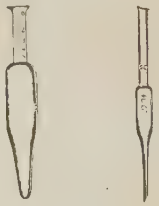

Fig. 30.
Test bottle and pipette for physician's centrifuge.

840. **Whitman milk bottle.** Dr. Ross C. Whitman has devised another milk test bottle for the special use of physicians in testing human milk and small amounts of cow's milk by the Babcock test.[1] The bottle, which can be placed in an ordinary urine centrifuge, consists of two parts, a small tube for holding the milk, acid and water, and a detachable graduated fine t ube, into which the fat column is brought after the final filling and whirling. 5 cc. of milk are used in this test.

[1] Jour. Amer. Med. Asso., 47 (1906), p. 204. See also Doran, Jr. Ind. and Eng. Chemistry, 1912, p. 841.

Questions.

1. Give a brief description of the Babcock test.

2. State precautions to be observed in each of the following operations: (a) Measuring the milk, (b) adding the acid, (c) whirling the bottles, (d) adding the water, (e) measuring the fat. If the fat separates clear, but the results are evidently too low, what is the probable cause, and how can the correct test be established?

3. To what extent does the temperature of the fat, when read, influence the result?

4. Explain the graduations of the milk test bottle.

5. What is the capacity of the neck of a milk test bottle between the 0 and 10 marks, expressed in cc., and in grams?

6. If the graduations of a test bottle measure 2.3 cc. from 0 to 10%, what would be the correct test of a sample which reads 3.4% fat in this bottle?

7. Describe three different methods of calibrating milk test bottles.

8. Describe the proper construction of the milk-measuring pipette; what weight of milk does it deliver?

9. What is a Swedish acid-bottle?

10. What speed is required for testers having a diameter of 8, 15, and 20 inches?

11. Write an order for one gallon of sulfuric acid to be used in testing milk.

12. How can the strength of the acid be tested at the farm or in a factory?

13. State precautions to be taken in using an acid that is (a) too strong, (b) too weak.

14. What does the color of the fat indicate in regard to the strength of the acid or the temperature of either acid or milk?

15. What is the cause of foam above the fat column, and how may it be prevented?
16. What causes white curd or black specks in the fat?
17. Describe a few modifications of the Babcock test.

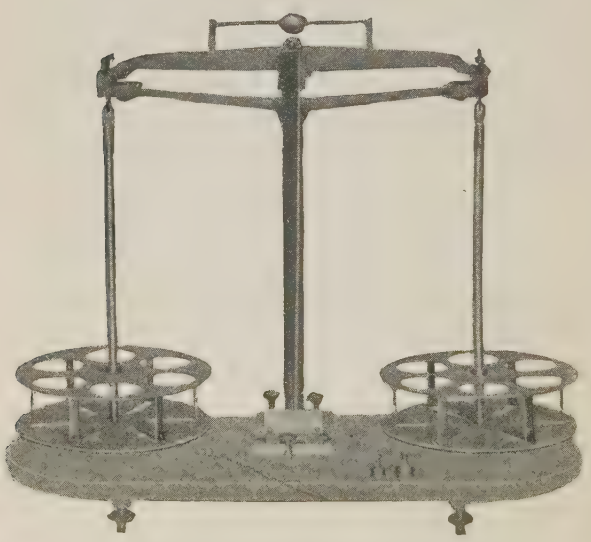

Fig. 30a. Scales used for weighing cream in the Babcock test.

CHAPTER IV.

CREAM TESTING.

85. Cream may be tested by the Babcock test in the same manner as milk, and the results obtained are accurate when the necessary care has been taken in sampling the cream and measuring the fat. The composition of cream varies greatly according to the process of creaming, the temperature of the milk during the creaming, the quality and the composition of the milk, etc. The cream met with in separator creameries will contain from 25 to 40 per cent. of fat, or on the average about 35 per cent. Cream from hand separators may be as rich as this, but it often contains only 20 per cent.

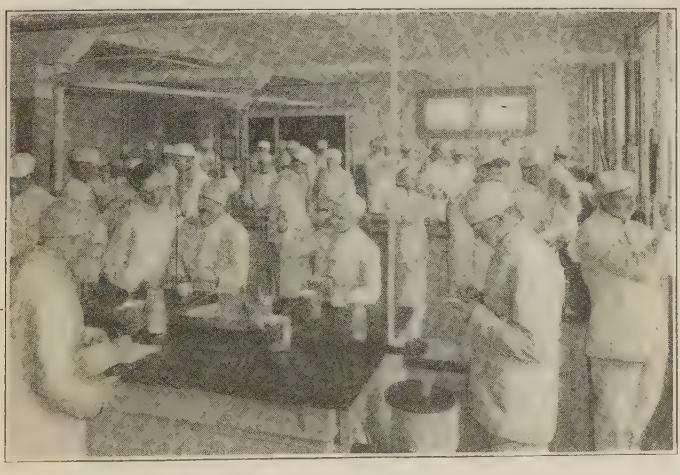

FIG. 31. Students testing dairy products.

of fat as delivered to creameries. An average grade of market cream as retailed contains about 25 per cent. of fat. If 18 grams of 25 per cent. cream are measured into an ordinary Babcock test bottle, there will be $18 \times .25 = 4.5$ grams of pure butter fat in the bottle, or, (since the specific gravity of butter fat is about .9) $\frac{4.5}{.9} = 5$ cc. It is shown that the space from 0 to 10 in the neck of these bottles holds exactly 2 cc. (44). The neck of the milk test bottle is not large enough to show the per cent. of fat in a sample of cream if 18 grams are taken for testing, and it is therefore necessary to adopt special measures when cream is to be tested.

86. Errors of measuring cream. Several factors tend to render inaccurate the measuring of cream for the Babcock test, and correct results can therefore only be obtained by weighing the cream. If a 17.6 cc. pipette is used in testing the cream, it will not deliver 18 grams of cream, as it will of milk, for the following reasons:

1. The specific gravity of cream is lower than that of milk; if a certain quantity of milk weighs 1030 lbs., the same quantity of cream will weigh from 1020 lbs. to 1000 lbs. or less, the weight being determined by the richness of the cream; the more fat the cream contains, the less a certain quantity of it, e. g., a gallon, will weigh.[1]

2. Cream is thicker (more viscous) than milk at the same temperature, and more of it will adhere to the sides of the measuring pipette than in the case of milk.

[1] For specific gravity of cream of different richness, see table on p. 77

This is of special importance in testing very rich or sour cream.

3. In case of separator cream, more or less air will become incorporated with the cream during the process of separation. In the ripening of cream, the fermentation gases developed are held in the cream in the same way as bread dough holds the gases generated by yeast. In either case the weight of a certain measure of cream is diminished.

87. As an illustration of the effect of the preceding factors on the amount of cream measured out by a Babcock 17.6 cc. pipette, the following weighings of separator cream are given (column *b*.) The cream was in all cases fresh from the separator; it was weighed as delivered by the pipette into a cream test bottle (89), and the test proceeded with at once; the specific gravity of the cream was determined by means of a picnometer (248). The data given are in all cases averages of several determinations; the samples of cream have been grouped according to their average fat contents.[1]

Per cent of fat. in cream.	*Specific gravity (17.5° C.) (a)*	*Weight of cream delivered, grams. (b)*
10	1.023	17.9
15	1.012	17.7
20	1.008	17.3
25	1.002	17.2
30	.996	17.0
35	.980	16.4
40	.966	16.3
45	.950	16.2
50	.947	15.8

[1] For influence of condition of cream on the amount measured out with a 17.6 cc. pipette, see also Bartlett, Maine exp. sta., bull. 31 (S. S.); Jones, Vt. exp. sta., report 16, 101–6, and Dean, Guelph (Ont.) agr college, report 1906, p. 125.

The figures in the table show plainly the variations in the specific gravity of cream of different richness and the error of making tests of cream by measuring it with a 17.6 cc. pipette, especially if the pipette is not rinsed and the washings added to the test bottle. If the cream to be sampled is fresh separator cream testing over 30 per cent., less than 17.0 grams of cream will be delivered into the test bottle, and the results of the reading will be at least one-eighteenth too low (since the bottles are graduated for 18 grams), or about 1.6 per cent. too low in the case of a 30 per cent. cream. If the cream is sour, the error will of course be still greater.

It should be remembered that the specific gravities of the cream given in the table refer to fresh separator cream only. Considerable air is incorporated during the separation, and cream of this kind is therefore lighter than gravity cream of corresponding fat contents.

Babcock has calculated the specific gravity of cream containing different percentages of butter fat, and the weight of one gallon of each; see table XVI in the Appendix.[2]

88. Weighing cream for testing. For the reasons stated in the preceding, accurate tests of cream can only be made by weighing the cream into the Babcock test bottles.[1]

The simplest method is to weigh 9 or 18 grams of the samples on a small cream-weighing scale (see p. 81) into one of the special forms of cream-test bottles.

[1] This is recognized by a law passed by the Wisconsin legislature in 1903, and by similar laws in other states which require cream to be weighed for testing where it is sold on the basis of its fat content. (Chapter 43, Wisconsin laws of 1903, an act to prescribe the standard measures for the use of the Babcock test in determining the per cent. of butter fat in milk or cream.)

[2] Hoard's Dairyman, Jan. 10, 1910.

Cream-test bottles. Special forms of bottles have been devised for testing samples of cream by the Babcock test by Winton, Bartlett, and by various manufacturers.

89. The Winton cream bottle. The cream-test bottle devised by Winton,[1] (fig. 32), has a neck of the usual length, and of sufficient width to measure 30 or 50 per cent. of fat. The scale of the neck is divided into parts representing one-half of one per cent. each, but readings of a quarter of a per cent. can easily be estimated. Such readings of cream tests are sufficiently exact for most commercial purposes. This form of cream bottle will be found very convenient in making tests of composite samples of cream.

FIG. 32. The 30% cream test bottle.

FIG. 32a. 9-inch cream test bottle.

Cream test bottles of a small bore are greatly to be preferred to those with wide necks (fig. 33), since they permit of accurate readings to a quarter of a per cent.

Other forms of cream-test bottles which allow the testing of 50 or 55 per cent. cream have been placed on the market during late years by some manufacturers. These bottles (so-called 9-inch bottles) have long necks and require especially constructed, large and

[1] Connecticut experiment station (New Haven), bull. 117; report 1894, p. 224.

deep testers (see fig. 25). These machines and accompanying bottles have of late been adopted for cream testing in many localities where farm separator cream is delivered to the creameries.

90. The bulb-necked cream test bottles allow the testing of cream containing 23 or 25 per cent. of fat, when the usual quantity of cream (18 grams) is taken. The neck is graduated from 0 to 23 per cent., and in some cases to 25 per cent., the graduation extending both below and above the bulb. This is sometimes an inconvenience, as the water must be added carefully so that the lower end of the column of fat will always come below the bulb, in the graduated part of the neck, and not in the bulb itself. Beginners are especially apt to lose tests when this bottle is first used, for the reason given. It is recommended to fill these bottles with the first portion of hot water to just above the bulb, so that one can see how much water to add the second time in order to bring the fat within the scale.

FIG. 33. The 50% cream test bottle.

Each division of the scale on these cream bottles represents two-tenths of one per cent. of fat, as in case of the milk test bottles. This form of bottle is no longer used to any extent, as it has been largely replaced by the different forms of the Winton cream-bottle.

FIG. 33a. The 50% 9 gram cream test bottle.

91. Scales for weighing the cream. When a small, delicate balance is used, cream can be weighed rapidly into the bottles. Either of the scales shown in the accompanying illustrations, (figs. 34-35), will be found sufficiently accurate for this purpose; a small scale of this kind is also convenient and helpful in testing cheese, butter and condensed milk, in deter-

mining the strength of sulfuric acid, and in testing the accuracy of test bottles and pipettes.

Cream scales similar to that shown in fig. 35 permit the weighing of two or four samples of cream at a time with only one taring of the bottles, which greatly facilitates the work of testing the cream.

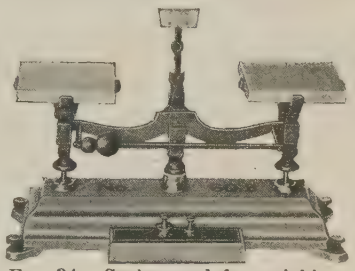

FIG. 34. Scales used for weighing cream in the Babcock test.

In testing cream by weighing, the test bottle is first weighed empty, and again when 9 or 18 grams of cream have been placed in it; the difference between the two figures gives the weight of cream taken for the test. If the cream contains less than 30 per cent. of fat, the regular milk test bottle can also be used for testing the cream, if not much more than 5 grams are weighed out; if more cream is taken, or if this is richer than 30 per cent., it is advisable to use special cream bottles.

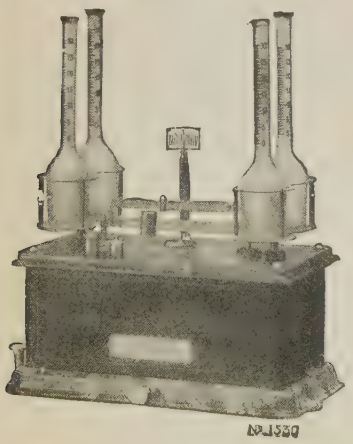

FIG. 35. Torsion balance used for weighing cream in the Babcock test.

The operator should be careful in weighing the cream not to spill it on the outside of the test bottle. If less than 18 grams of cream has been weighed into the bottle sufficient

water is added to the balance to make the total volume about 18 cc. The usual quantity of acid (17.5 cc.) is then added, and the test completed in the ordinary manner. The reading of the amount of fat in the neck of the test bottle will not show the correct per cent. of fat in the cream unless exactly 18 grams are weighed out. If less than this weight was taken the per cent. of fat in the cream tested is obtained by multiplying the reading by 18, and dividing the product by the weight of cream taken.

EXAMPLE: Weight of cream tested, 5.2 grams; reading of column of fat [1])9.8, [2])9.7, average 9.75; per cent. of fat in the cream $\frac{9.75 \times 18}{5.2} = 33.75$.

It is very convenient to weigh out 18 grams of cream (or 9 grams) so that the readings may be taken directly from the neck of the bottle. The smaller the quantity of cream taken for a sample, the greater is the error introduced by inaccurate weighings or readings. The result is rendered more accurate if two or three tests of a sample are made, and the readings averaged.

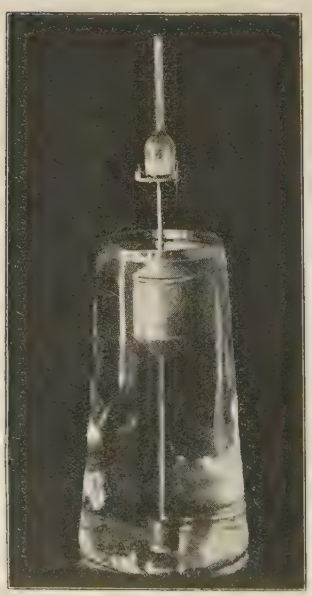

FIG. 35a. The Wisconsin hydrostatic cream balance.

91a. The hydrostatic balance is a convenient device for weighing cream and other dairy products to be tested by the Babcock test (see fig. 35a).[1] This balance

[1] Wisconsin exp. station, bull. 195.

is built on the same principle as a lactometer: it is provided with a pan on the top of the stem, on which the test bottles and the weights are placed. When put into water the instrument is balanced to a certain point with empty test bottles and weights on the pan; the weights are then removed and sufficient cream added to the test bottle by means of a pipette to sink it to the same point as before.

The special advantages of the balance are that there are no bearings to rust and become dull; it is durable, inexpensive and sensitive, and with careful handling will remain sensitive indefinitely. The balance can be made large enough to weigh a number of bottles at a time, as is the case with some of the cream scales on the market.

92. Measuring cream for testing. Where a special cream scale or a small balance is not available, fairly satisfactory results may be obtained with cream of low or average quality by measuring out the sample with a 17.6 pipette and correcting the results as indicated below. One of the cream test bottles or a common milk test bottle may be used for this purpose. The table on p. 77 shows that a 17.6 cc. pipette, in the case of cream fresh from the separator, containing less than 25 per cent. of fat, will deliver only 17.2 grams of cream, that is, the results will be $\frac{.8\times25}{18}=1.1$ per cent. too low. In the same way in case of 40 per cent. cream, only 16.3 grams of cream would be delivered, and the results therefore 3.8 per cent. too low. When the cream has been ripened or is thick, less cream would be delivered than the amounts given, and the error introduced by measuring out the samples correspondingly increased.

A table of correction for testing such cream by measuring the samples has been prepared by Prof. Eckles, formerly of Iowa experiment station.[1]

Approximately correct results may be obtained in testing thin cream by using an 18 cc. measuring pipette; to avoid the expense and trouble of using two different pipettes, one for milk and one for cream, a pipette with two marks on the stem, at 17.6 cc. and 18 cc., has been placed on the market, the former mark being used when milk is tested, and the latter for cream. It should be borne in mind, however, that such pipettes can only be used in the case of sweet cream of average richness, and will then give only approximately correct results.

93. Use of milk test bottles. Cream may be tested by emptying a 17.6 cc. pipetteful into two or more milk test bottles, dividing the sample about equally between the bottles and filling the pipette with water once or twice, which is then in turn divided about equally between the test bottles; the per cent. of fat in the cream is found by adding the readings obtained in each of the bottles. The cream and the water must be mixed *before* the acid is added.

This method does away with the error incident to the adhesion of cream to the side of the pipette, but not

[1] Press bull. dated August, 1901. Some creameries heat the samples of cream in a water bath to about 140° F. before the test samples are measured out by means of a 17.6 cc. pipette. This increases the fluidity of the cream and causes less to adhere to the pipette. The Vermont experiment station (report 16, pp. 191–6) found in examining this method that it did not yield satisfactory results in the case of cream of different richness and recommends that cream be weighed when accurate tests are desired.

that due to the low specific gravity of the cream, and the results obtained will therefore be too low.

The dilution of the cream with water in the test bottles not only makes it possible to bring into the bottle all the cream measured out, but also insures a clear test. If ordinary cream is mixed with the usual quantity of sulfuric acid used in the Babcock test, a dark-colored fat will generally be obtained, while the cream diluted with an equal or twice its volume of water, when mixed with the ordinary amount of acid, will give a light yellow, clear column of fat, which will allow of a very distinct and sharp reading.

The number of bottles to be used for testing a sample of cream by this method must be regulated by the richness of the cream. If the sample probably contains 20 per cent. or more, a pipetteful should be divided about equally between three milk test bottles, and two-thirds of a pipetteful of water is added to each bottle. If the cream contains less than 20 per cent. of fat, it will only be necessary to use two milk test bottles, dividing the pipetteful between these, and adding one-half of a pipetteful of water to each bottle.

By using cream test bottles (89), more accurate tests may be obtained in case of cream containing as much as 25 per cent. of fat, by dividing one pipetteful between two bottles, rinsing half a pipette of water into each one, than by adding all the cream to one bottle without rinsing the pipette, for reasons apparent from what has been said in the preceding.

94. Use of a 5 cc. pipette. When the cream is in good condition for sampling, satisfactory results can also be obtained by the use of a 5 cc. pipette, provided great care is taken in mixing the cream before sampling; 5 cc. of cream are measured into a milk test bottle, and two pipettefuls of water are added. In this way all the cream in the pipette is easily rinsed into the test bottle. The readings multiplied by $\frac{18}{5}=3.6$ will give the per cent. of fat in the cream. If the specific gravity of the cream tested varies appreciably from 1, corrections should be made accordingly; e. g., if the specific gravity is 1.02, the factor should read $\frac{18}{5\times1.02}=3.53$; if .95, $\frac{18}{5\times.95}=3.79$, etc.

95. Proper readings of cream tests. The accompanying illustration (fig. 36), shows the proper method of reading the fat column in cream tests; readings are taken from *a* to *c*, not to *b* or to *d*, when readings are made at 140° F.[1]

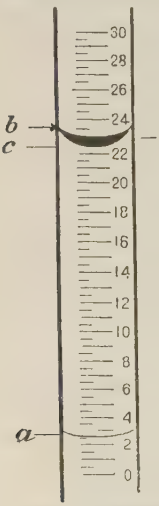

FIG. 36. Measuring the fat column in the neck of a cream bottle. Reading should be made from *a* to *c*, not to *b* or to *d*.

No special precautions other than those required in testing milk have been found necessary in testing cream, except that it is sometimes advisable not to whirl the test bottles in the centrifuge at once after mixing, but to let the cream-acid mixture stand for a while, until it turns dark colored. At first, the mixture of cream and acid is much lighter colored than that of milk and acid, owing to the smaller proportion of solids not fat contained in the cream.

The liquid beneath the fat in a completed test of cream is sometimes milky

[1]The size of the meniscus is magnified in this cut. A study of the meniscus formed in bottles with narrow or wide necks, and its

and the fat appears white and cloudy, making an exact reading difficult. Such defects can usually be overcome by placing the test bottles in hot water for about ten minutes previous to the whirling, or by allowing the fat to crystallize (which is done by cooling the bottles in cold water after the last whirling) and remelting it by placing the bottles in hot water.

The error due to the expansion of the fat in case of excessively hot turbine testers having no openings in the cover as mentioned on p. 36, is especially noticeable in cream testing, where it may amount to one per cent. or more. In order to obtain correct results with such testers, the hot cream test bottles must be placed in water at about 140° F. for some minutes before the results are read off.

The subject of different methods of reading cream tests have been studied by Webster and Gray,[1] who conclude that correct results are obtained by taking readings at 120° F., from the bottom to the extreme top of the fat column, deducting four-fifths of the depth of the meniscus from this result and adding .2 per cent. to the figure thus obtained.

96. Eliminating the meniscus in cream tests. The uncertainty concerning the exact point at which the meniscus of the fat column should be read in cream tests has been removed by the use of certain liquids which do not mix with fat but which when dropped on

bearing on the results of cream tests is given in bulletin 58, Bur. An. Ind., U. S. Dept. of Agriculture, where a discussion of the influence of different temperatures on readings of cream tests will also be found (see 96).

[1] Bull. 58, Bur. An. Ind., U. S. Dept. of Agriculture. See also Mass. rept., 1909, p. 142.

top of the fat column change the curved surface of the meniscus into a straight line. *Amyl alcohol, fat-saturated alcohol* and *glymol* have been suggested for this purpose.

Amyl alcohol colored red by fuchsin was suggested by Eckles.[1] This may dissolve some of the fat and thus cause a slightly low reading. *Fat-saturated alcohol*[2] largely overcomes this objection. It is made by adding about a teaspoonful of butter to six ounces of denatured or wood alcohol in a stoppered bottle. This is warmed slightly and shaken until the alcohol does not dissolve any more of the fat. A small amount of coloring matter may be added to this solution to further facilitate the reading. The use of *glymol*[3] or white mineral typewriter and sewing machine oil was suggested by Hunziker for reading cream tests, after an exhaustive study of the subject. Glymol may be colored with alkanet root which can be obtained from a druggist. One ounce of alkanet root will color one quart of glymol; this is done by placing a small cheese cloth bag filled with the alkanet root in the bottle of glymol for one or two days.

Fig. 36a. Showing the use of fat-saturated alcohol, glymol, etc., for eliminating the meniscus in cream tests.

A convenient way of adding alcohol, glymol, etc., to the fat column after completing a test is to insert a

[1] N. Y. Produce Review, Aug. 8, 1908.
[2] Wis. Expt. Sta. Bul. 195, p. 6.
[3] Purdue, Ind., Expt. Sta. Bul. 145, vol. XV, p. 593.

glass tube through a cork or stopper of a bottle containing the liquid; by placing a finger on the top of the tube a small portion may be transferred from the bottle to the top of the fat column. By the use of either of the liquids mentioned the meniscus in cream tests disappears, giving a straight line at the top as well as the bottom of the fat column and thus making it possible to obtain exact readings of the per cent. of fat in any sample of cream.

Questions.

1. Give three reasons for weighing cream for testing.
2. How does the richness of the cream influence its weight?
3. What is the weight of one gallon of cream testing 10, 30, or 50% fat?
4. Describe at least three forms of cream test bottles.
5. What purpose does the bulb in the cream-test bottle serve?
6. Between what points should the cream fat column be read?
7. If cream was erroneously weighed into a test bottle as 9.3 gr. instead of 10 gr., what error would this cause on a sample testing 33% fat?
8. Mention a few important points in the construction of a cream test bottle.
9. If 12.5 gr. cream give a reading of 18.5, what is the correct test of the sample?
10. If 7.2 gr. of cream give a reading of 6.4, what is the correct test of the sample?
11. If the fat in a cream test is read as 28% at a temperature of 180° F., what is the correct test?
12. If at the end of a full day's run 4,280 lbs. of milk had been received, testing 3.95 per cent., and 535 lbs. of cream testing 34.5 per cent. fat; how much fat (a) in the whole milk; (b) in the cream; (c) in the skim milk? (d) what would be the test of the skim milk, (e) how many pounds of skim milk would there be; and (f) what would be the per cent. of cream from the milk?

CHAPTER V.

BABCOCK TEST FOR OTHER MILK PRODUCTS.

97. Skim milk. Each division on the scale of the neck of the regular Babcock test bottle represents two-tenths of one per cent. (44). When a sample of skim milk or butter milk containing less than this per cent. of fat is tested, the estimated amount is expressed by different operators as one-tenth, a trace, one-tenth trace, or one- to five-hundredths of one per cent. Gravimetric chemical analyses of skim milk have, however, shown that samples which give only a few small drops of fat floating on the water in the neck of the test bottle, or adhering to the side of the neck, generally contain one-tenth of one per cent. of fat, and often more. Samples of skim milk containing much less than one-tenth of a per cent. of fat are very rare, and it is doubtful whether a sample of separator skim milk representing a run of, say 5000 lbs. of milk, will ever show less than five-hundredths of one per cent. of fat. Under ordinary factory conditions, few separators will deliver skim milk containing under one-tenth of one per cent. of fat, when the sample is taken from the whole day's run. This must be considered a satisfactory separation.[1]

[1] For comparative analyses of separator skim milk by the gravimetric method and by the Babcock test, see Wis. exp. station bull. 52 and rep. XVII, p. 81; Conn. (Storrs) exp. station, bull. 40; Utah exp. station, bull. 96. See also, Woll, Testing Skim Milk by Babcock Test, in *Country Gentleman*, April 26, 1902. The results obtained by the use of the Gottlieb method have shown that ether-extraction methods, as

98. The reason why the Babcock test fails to show all the fat present in skim milk must be sought in one or two causes: a trace of fat may be dissolved by the sulfuric acid, or owing to the minuteness of the fat globules of such milk they are not brought together in the neck of the bottles at the speed used with the Babcock test. The latter cause is the more likely explanation. If a drop of the dark liquid obtained in a Babcock bottle from a test of whole milk be placed on a slide under the microscope, it will be seen that a fair number of very minute fat globules are found in the liquid. These globules are not brought into the column of fat in the neck of the bottle by the centrifugal force exerted in the Babcock test, even if the bottles are whirled in a turbine tester in which they are heated to 200° F. or higher (see 71); the loss of the fat contained in these fine globules is compensated for, in the testing of whole milk, by a liberal reading of the fat column, this being taken from the bottom of the fat to the top of the upper meniscus (see p. 35); in some separator skim milk, on the other hand, not enough fat remains to completely fill the neck, and the reading must therefore be increased by at least five-hundredths of one per cent.

It follows from what has been said that tests of skim milk showing but a drop or two of fat in the neck of the test bottles on completion of the test, generally indicate inefficient work of the centrifugal tester or of

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well as the Babcock test, give too low results with dairy by-products low in fat, like skim milk, butter-milk, etc. The Gottlieb method for this reason has been adopted by European chemists as a standard for analysis of these products. (See 254).

the operator, or of both. The test should be repeated in such cases, using more acid and whirling for full five minutes. Separator skim milk should be allowed to stand 10 to 15 minutes before the sample is taken so as to allow the air to escape.

In order to bring as much fat as possible into the neck of the bottles in testing skim milk, it is advisable to add somewhat more acid than when whole milk is tested, viz., about 20 cc., and to whirl the bottles at full speed for at least five minutes, keeping the tester as hot as possible the whole time.[1] The readings must be taken as soon as the whirling is completed, since owing to the contraction of the liquid by cooling, the fat will otherwise adhere to the inside of the neck of the test bottle as a film of grease which cannot be measured by the scale.

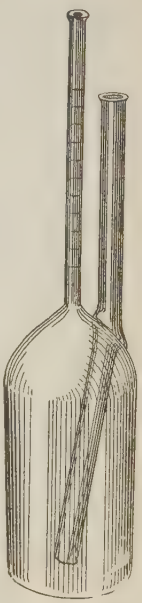

FIG. 37. The double-necked skim milk bottle (sometimes called the Ohlson or B. & W. bottle).

99. The double-necked test bottle, (fig. 37), suggested by one of us,[2] is made especially for measuring small quantities of fat and gives fairly satisfactory results in testing skim milk and butter milk. Generally, each division of the scale on these bottles represents five-hundredths of one per cent., and the marks are so far apart that the small fat column can be easily estimated to single hundredths of

[1] See Wis. exp. station, report 17, p. 81.

[2] First constructed by Mr. J. J. Nussbaumer, of Illinois; now manufactured by various firms.

one per cent. In the first forms, now out of use, the neck was graduated to hundredths of one per cent.

The value of the divisions of the scale on the double-necked test bottles has been a subject of considerable discussion, and various opinions have been expressed whether they show one-tenth or one-twentieth (.05) of one per cent. of fat. By calibration with mercury the value of the divisions will be found to be .05, or one-twentieth, of one per cent., but as shown above, the results obtained in using the bottles for separator skim milk generally come at least .05 per cent. too low, so that, practically speaking, each division may be taken to show one-tenth of one per cent., if the fat fills only one division of the scale or less.[1]

The double-necked bottle is very convenient for the testing of separator skim milk, thin butter milk and whey. The milk, acid and water are added to the bottle through the filling-tube; the mixing of milk and acid must be done with great care, so that none of the contents is forced into the fine measuring tube and lost; it is best to add half of the acid first and mix it with the milk, and then add the rest. When the fat is in the lower end of the measuring tube, it can be forced into the scale by pressing with the finger on the top of the side tube.

In placing the double-necked bottles in the tester they should be put with the filling tube toward the center, so as to avoid any of the fat being caught between this tube and the side of the bottle when it resumes a vertical position.

1 Wisc. exp. sta., bull. 52; Penna. exp. sta., report 1896, p. 221.

This test bottle is more fragile and expensive than the ordinary Babcock bottles, and must be carefully handled; it is now generally made of heavier glass than formerly, and this form is to be highly recommended.[1] (See fig. 38.)

100. The double-size skim milk bottle which was the first one recommended for the testing of skim milk, is of no particular value. It is difficult to obtain a thorough mixture of the milk and the acid in these bottles, and the tests invariably come too low, more so than with the regular Babcock bottles or double-necked skim milk bottles, for reasons that are readily seen.

101. Buttermilk and whey. The testing of buttermilk by the Babcock test offers no special difficulties if the special directions for testing skim milk are followed; what has been said in regard to tests of separator skim milk is equally true in case of this by-product. Whey contains only a small quantity of solids not fat, viz., less than 7 per cent. (27), and the mixing with acid and the solution of the whey solids therein is therefore readily accomplished; the acid solution is of a light reddish color, turning black but very slowly.

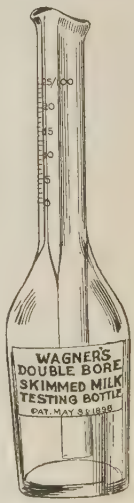

FIG. 38.
The double-bore skim milk bottle.

102. Butter. Butter is not so easily tested as other dairy products, both because of the difficulties in obtaining a fair sample, and on account of the high percentage of fat it contains. Butter is a mechanical mix-

[1] A double-necked copper test bottle with a detachable graduated glass neck was designed and tried by one of us a few years ago, but it was not found to possess any special advantage over the glass bottle.

ture of water, curd, and salt, with butter-fat; and the water or brine is so easily pressed out that great care must be taken to get the same amount of water in the small portion to be tested as exists in the lot of butter sampled.

Sampling butter. Small portions of butter are taken with a butter trier or a knife from different parts of the tub, package, or churning of butter to be tested. These small portions (preferably about 200 grams in all) are placed in a wide-necked bottle or jar which is securely stoppered and placed in warm water until the butter melts. The jar is then shaken vigorously in order to obtain a thorough mixing of the various components of the butter, and placed in cold water. As the butter cools, the jar must be shaken repeatedly until the butter either solidifies or becomes of a thick creamy consistency. From this sample small portions may be taken for testing.

It is not always necessary to prepare a sample of butter for testing in the manner described. If the butter contains no loose drops of brine on the freshly-cut surface, a sample for testing can be taken directly from the package. The operator must use his judgment in regard to the necessity of preparing a special sample in each case.

Scales for weighing butter. In testing butter it is necessary to weigh the amount taken for a test very accurately. Scales sensitive to less than .05 gram should be used, as a difference of .1 gram in weight has a value of 1.0 per cent. in the result when 10 grams of butter are tested. Slow-working scales with rusted bearings are worthless for testing butter. The scales should

always be balanced before being used and the weights kept bright and clean.

Carelessness in weighing may be the cause of very inaccurate results, and the importance of a sensitive scale cannot be over-estimated. Scales with a graduated side beam are preferable to those that require the use of small weights. Scales sensitive to .01 gram are now on the market, which permit of 20 to 50 grams of butter being weighed out for testing.[1]

103. Fat in butter. The Babcock test can be used with only a fair degree of accuracy for estimating the per cent of fat in butter, by weighing 9 grams of butter into a test bottle graduated to measure 50 per cent. fat. About 10 cc. of hot water is added to the butter, and 17.5 cc. of sulfuric acid of one-half the strength used in milk testing. Mix the butter and acid until the curd is all dissolved, add hot water to bring the fat into the neck of the test bottle and whirl in a centrifuge. When a clear separation of the fat is obtained the test bottle is placed in water of 140° F. up to near the top of the neck and after standing a few minutes in this water the fat column is read off; the reading multiplied by 2 gives the per cent. of fat.

Fairly accurate results can only be obtained by taking great care in all the manipulations, especially in weighing the butter and in reading the fat at the proper temperature. Small errors in making tests have a marked influence on the results, because the butter fat is such a large per cent of the butter. Tests should always be made in duplicate, and even then results are only approximately correct.[2]

[1] See bull. 154, Wisconsin exp. sta., p. 10.

[2] Special bottles for testing butter for its fat content have been put

104. Cheese. Cheese can be easily tested by the Babcock test if a small scale (fig. 58b) is at hand for weighing the sample; the results obtained will furnish accurate information as to the amount of fat in the cheese, provided good judgment and exactness are used in sampling and weighing the cheese. For inspection purposes the rind may be rejected, but for investigations, where the absolute quantity of fat in the cheese is required, the rind should be included in the sample.[1] The following method of sampling cheese is recommended.

105. Draw a plug from a sound portion of the cheese with a cheese trier; this should be taken at a point that is not near the rind, a cut surface of the cheese, a defective spot or an old trier hole. Cut off the top one-half inch of the trier plug and replace it in the trier hole to protect the cheese; then cut the plug of cheese lengthwise into four pieces and slip two of these into the neck of a cream test bottle which has been previously weighed empty.

After adding 8 to 10 grams of the cheese in this way the test bottle should be weighed again and the exact weight of cheese taken for testing is obained by subtraction.

10 cc. of boiling water is then added to the test bottle by using a wide tipped pipette, and acid is added immediately in portions of about 1 cc. each at first, shaking the bottle for a second after each addition of acid.

on the market, e. g., the Wagner Butter Test Bottle and the form suggested by H. R. Wright, given in the 18th report of the Iowa State Dairy Commissioner, 1904, p. 40.

[1] U. S. Dept. of Agriculture, Chemical Division, bull. 46, p. 37.

This method of adding the acid gradually to the hot water and cheese in the test bottle produces a temperature high enough to melt the cheese immediately so that the test bottle may be placed in the centrifuge at once and the fat separated and measured in the usual way for testing cream.[1]

The per cent. of fat in the cheese is obtained by multiplying the reading of the fat column by 18 and dividing the product by the weight of cheese. The weighing of the cheese and the reading of the fat must be done very carefully, since any error introduced is more than trebled in calculating the per cent. of fat in the cheese.

106. Condensed milk. The per cent. of fat in *unsweetened* condensed milk can be obtained by weighing about 9 grams into a test bottle and proceeding in exactly the same way as given under testing of cheese. It is not necessary to warm the condensed milk in the test bottles, since this is readily dissolved in water. Enough water should be added to make the total volume of liquid in the bottles 15 to 18 cc.

If a scale is not available for weighing the sample, fairly accurate results may be obtained by diluting the condensed milk with water (1:3), and completing the test in the ordinary manner. When this is done, the results must be corrected for the dilution which the sample received.

Hunziker[2] recommends adding hot, dilute sulfuric acid solution after the first whirling, in the analysis of unsweetened condensed milk (sulfuric acid and water,

[1] See also Sammis, Journ. Ind. and Eng. Chem., I, p. 604.
[2] Ind. expt. sta., bull. 134.

1:1). He finds that this aids in giving a clear separation of the fat and obtaining satisfactory results.[1]

107. Sweetened condensed milk. The testing of *sweetened* condensed milk presents peculiar difficulties, whether it is to be tested by the Babcock test or by chemical analysis. It may, however, be readily tested by the Babcock test by using the methods given for testing ice cream.

The Mojonnier Tester. This is an apparatus designed especially for determining butter fat and total solids in condensed milk, ice cream, milk powder and other dairy products. It is based on the Rose-Gottlieb method (254). The manipulations of the method are much facilitated, and the time required for making the determinations are greatly reduced, by the use of this tester which includes a chemical balance, electric ovens, hot plates, motors, etc.

108. Ice cream. Methods for determining the per cent. of fat in ice cream have been worked out by Holm,[2] Howard[3] and others. On account of the tendency of ice cream to foam when melted, it should be mixed carefully by pouring a number of times from one

[1] For analysis of unsweetened condensed milk, see also Jr. Ind. and Eng. Chem., 1913, pp. 131 and 168. Good results may be secured by adding 3 cc. of a mixture of equal parts of amyl alcohol and C. P. hydrochloric acid to the milk, then 10 cc. of C. P. sulfuric acid, and proceeding as given above (Amott).

The Gottlieb method gives very satisfactory results with both cheese and condensed milk (see 254). See also Jr. Ind. and Eng. Chem., 1912, p. 672. For method of analysis of desiccated milk, milk powder, etc., see ibid., 1912, p. 544.

[2] Report Dept. of Health, City of Chicago, 1906, p. 50.

[3] Journ. Am. Chem. Soc., 1907, p. 16. Methods of analysis of ice cream have also been proposed by White, (Penna. exp. sta., rept. 1910, p. 243), Baird, (N. Y. Prod. Rev., Feby. 26, 1913), and Halvorsen, (Jr. Ind. and Eng. Chem., 5 (1913), p. 403).

vessel into another and instead of measuring with a pipette, about 9 grams are poured rapidly into a cream-test bottle which should be weighed empty and again after adding the ice cream. This may be tested by either the sulfuric-acid or the nitric-acid test.

Sulfuric acid only may be used successfully by adding it in small portions after about 10 cc. of warm water has been added to the ice cream in the test bottle. The amount of acid required is shown by the color of the mixture which becomes dark brown as the portions of acid are added and mixed with the ice cream. When this color is obtained, further action of the acid is stopped by adding a little cold water to the mixture in the test bottle which is then placed in a centrifuge and the test completed in the usual way.

Holm recommends the use of a mixture of equal parts of hydrochloric and glacial acetic acid, in place of sulfuric acid, as the latter may char the sugar in the ice cream, thus giving difficulty in reading the results. Nine grams of either the frozen or melted sample are weighed into a Babcock milk bottle, which is then filled almost to the neck with the mixture of the two acids given. This is heated for a few minutes until black, when the bottle is whirled in the tester and water added to bring the fat column within the graduations of the neck, as in the regular Babcock test. The reading multiplied by two gives the per cent. of fat in the ice cream.[1]

[1] An apparatus for determining the amount of *overrun* (214) in the manufacture of ice cream has been devised by G. H. Benkendorf of Wis. exp. station (see bull. 239 of the station).

The co-called nitric-acid test of ice cream is made as follows: first, prepare a mixture of 12 cc. concentrated nitric acid and 88 cc. sulfuric acid (sp. gr., 1.82-1.83); second, weigh 18 grams of the sample of ice cream into a beaker; third, add about 9 cc. of this acid mixture to the ice cream in the beaker and mix cautiously. When the foam subsides, notice the color of the mixture; if it is dark brown, no more acid is needed, but if the ice cream is not at all dissolved, add more of the acid mixture until a clear, chocolate-colored liquid is obtained. The contents of the beaker may then be rinsed into a cream-test bottle, using a little hot water to clean out the beaker. The test bottle is then placed in a centrifuge and the test completed in the usual way.[1]

Questions.

1. Why is it difficult to get accurate tests of skim milk by the Babcock test?
2. Mention at least three precautions that should be taken in testing skim milk.
3. Should more acid be used for full milk than for skim milk, or more for skim milk than for whey? Why?
4. How much fat is probably present in a sample of skim milk which shows no fat on being tested in a skim milk bottle?
5. What per cent. of fat does each division of a double-necked skimmilk test bottle represent?
6. How can (a) butter, (b) cheese, (c) unsweetened and sweetened condensed milk be tested with the Babcock test?
7. If 8.4 gr. cheese give a reading of 12.2% on the neck of a test bottle, what per cent. of fat does the cheese contain?
8. What is the per cent. of fat in a sample of cheese, of which 4.2 grams contained enough fat to fill the space in the neck of a Babcock milk test bottle from 1.7 to 9.5 mark?
9. How can the per cent. of fat in ice cream be determined?

[1] Wisconsin exp. station bull. 262.

CHAPTER VI.

THE LACTOMETER AND ITS APPLICATION.

109. The lactometer is used for determining the specific gravity of milk. The term *specific gravity* means the weight of a certain volume of a solid or a liquid substance compared with the weight of the same volume of water at 4° C. (39.2° Fahr.); for gases the standard of comparison is air or hydrogen. If the milk which a can will hold weighs exactly 103.2 lbs., this can will hold a smaller weight of water, say 100 lbs., as milk is heavier than water; the specific gravity of this milk will then be $\frac{103.2}{100} = 1.032$.

The specific gravity of normal cow's milk will vary in different samples between 1.029 and 1.035 at 60° F., the average being about 1.032. The specific gravity of skim milk is about 1.036-1.038, and of sweet cream 1.01 to .95, according to the per cent. of fat contained therein; average specific gravity 1.0 (see p. 77).[1]

The lactometer enables us to determine rapidly the relative weight of milk and water. Its application rests on well-known laws of physics: When a body floats in a liquid, the weight of the amount of liquid which it replaces is equal to the weight of the body. It will sink further into a light liquid than into a heavy one, be-

[1] Since a gallon of water weighs 8.34 lbs., 1 gal. of milk will weigh 8.34×1.032 or 8.6 lbs.; 1 gal. of skim milk, 8.7 lbs., and 1 gal. of cream from 8.1 to 8.5 lbs., according to its richness. (See Table XVI, Appendix.)

cause a larger volume of the former will be required to equal the weight of the body. A lactometer will therefore sink deeper into milk of a low specific gravity than into milk of a high specific gravity.

110. The Quevenne lactometer. This instrument (fig. 39), consists of a hollow cylinder weighted by means of mercury or fine shot so that it will float in milk in an upright position, and provided with a narrow stem at its upper end, inside of which is found a graduated paper scale. In the better forms, like the Quevenne lactometer shown in the figure, a thermometer is melted into the cylinder, with its bulb at the lower end of the lactometer and its stem rising above the lactometer scale.

The scale of the Quevenne lactometer is marked at 15 and 40, and divided into 25 equal parts, with figures at each five divisions of the scale. The single divisions are called *degrees*. The 15-degree mark is placed at the point to which the lactometer will sink when lowered into a liquid of a specific gravity of 1.015, and the 40-degree mark at the point to which it will sink when placed in a liquid of a specific gravity of 1.040.

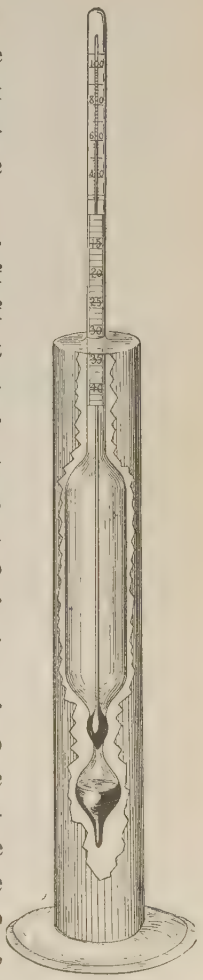

FIG. 39.

Quevenne lactometer floating in milk in a tin cylinder (115).

The specific gravity is changed to lactometer degrees by multiplying by 1000 and subtracting 1000 from the product.

EXAMPLE: Given, the specific gravity of a sample of milk, 1.0345; corresponding lactometer degree, $1.0345 \times 1000 - 1000 = 34.5$.

Conversely, if the lactometer degree is known, the corresponding specific gravity is found by dividing by 1000 and adding 1 to the quotient ($34.5 \div 1000 = .0345$; $.0345 + 1 = 1.0345$).

111. Influence of temperature. Like most liquids, milk will expand on being warmed, and the same volume will, therefore, weigh less when warm than before; that is, its specific gravity will be decreased. It follows then that a lactometer is only correct for the temperature at which it is standardized. If a lactometer sinks to the 32-mark in a sample of milk of a temperature of 60° F., it will only sink to, say 33, if the temperature of the milk is 50° F., and will sink farther down, e. g., to 31, if the temperature is 70° F. Lactometers are generally standardized at 60° F., and to show the correct specific gravity the milk to be tested should first be warmed (or cooled, as the case may be) to exactly 60° F.

112. Correction tables. Tables have been constructed for correcting errors in lactometer readings due to differences in temperature. As the fat content of a sample of milk has a marked influence on its specific gravity at different temperatures, the co-efficient of expansion of fat differing greatly from that of the milk serum, the table cannot give absolutely accurate

corrections for all kinds of milk, whether rich or poor. But the error introduced by the use of one table for all kinds of whole milk within a comparatively small range of temperature, like ten degrees above or below 60°, is too small to have any importance outside of exact scientific work, and in such, the specific gravity is always determined by means of a picnometer or a specific-gravity bottle (248), at the exact temperature at which this has been calibrated. In taking the specific gravity of a sample of milk by means of a lactometer, the milk is warmed or cooled, if need be, so that its temperature does not vary ten degrees either way from 60 degrees F.

113. The temperature correction table for whole milk, given in the *Appendix* shows that if, e. g., the specific gravity of a sample of milk taken at 68° F. was found to be 1.034, its specific gravity would be 1.0352 if the milk was cooled down to 60°. If the specific gravity given was found at a temperature of 51°, the corrected specific gravity of the milk would be 1.0329.

In practical work in factories or at the farm, sufficiently accurate temperature corrections may generally be made by adding .1 to the lactometer reading for each degree above 60° F., and subtracting .1 for each degree below 60°; e. g., if the reading at 64° is 32.5 it will be about 32.5+.4=32.9 at 60° F.; and 34.0 at 52° F. will be about 34.0—.8=33.2 at 60° F. The table in the *Appendix* gives 33.0 as the corrected figure in both cases.

The scale of the thermometer in the lactometer should be placed *above* the lactometer scale so that the tem-

perature may be read without taking the lactometer out of the milk; this will give more correct results and will facilitate the reading.

114. N. Y. Board of Health lactometer. In the East and among city milk inspectors generally, the so-called New York Board of Health lactometer is often used. This does not give the specific gravity of the milk directly, as is the case with the Quevenne lactometer; but the scale is divided into 120 equal parts, known as *Board of Health degrees,* the mark 100 being placed at the point to which the lactometer sinks when lowered into milk of a specific gravity of 1.029 (at 60° F.); this is considered the lowest limit for the specific gravity of normal cow's milk. The zero mark on the scale shows the point to which the lactometer will sink in water; the distance between these two marks is divided into 100 equal parts, and the scale is continued below the 100 mark to 120. As 100° on the Board of Health lactometer corresponds to 29° on the Quevenne lactometer, the zero mark showing in either case a specific gravity of 1, the degrees on the former lactometer may easily be changed into Quevenne lactometer degrees by multiplying by .29. To further aid in this transposition, Table III is given in the *Appendix,* showing the readings of the two scales between 60° and 120° on the Board of Health lactometer.

The temperature correction for Board of Health lactometers is as follows: for each degree of temperature above 60° F. .3 is added to the reading, and for each degree below, .3 is subtracted.[1]

115. Reading the lactometer. For determining the specific gravity of milk in factories or private dairies, tin or copper cylinders are recommended, 1½ inches in diameter and 10 inches high, with a base about four inches in diameter (see fig. 39); another form of specific-gravity cylinders, in use in chemical laboratories, is shown in fig. 40. The cylinder is filled with milk of a temperature ranging between 50° and 70° F., to within

[1] A special form of lactometer that will allow of very accurate readings has been constructed by Poetschke (see Jr. Ind. and Eng. Chem., 1911, p. 405).

an inch of the top, and the lactometer is slowly lowered therein until it floats; it is left in the milk for about half a minute before lactometer and thermometer readings are taken, both to allow the escape of air which has been mixed with the milk in pouring it, preparatory to the specific-gravity determination, and to allow the thermometer to adjust itself to the temperature of the milk. The lactometer should not be left in the milk more than a minute before the reading is taken, as cream will soon begin to rise on the milk, and the reading, if taken later, will be too high, as the bulb of the lactometer will then be floating in partially skimmed milk (24). In reading the lactometer degree, the mark on the scale plainly visible through the upper portion of the meniscus of the milk should be noted. Owing to surface tension the milk in immediate contact with the lactometer stem will rise above the level of the surface in the cylinder, and this must be taken into consideration in making the readings. It is not necessary to read closer than one-half of a lactometer degree in factory or dairy work.

FIG. 40. Specific-gravity cylinder.

116. Time of taking lactometer readings. The specific gravity of milk should not be determined until an hour or two after the milk has been drawn from the udder, as too low results are otherwise obtained (*Recknagel's phenomenon*).[1] The cause of this phenomenon is not definitely understood; it may come from the escape of gases in the milk, or from changes occurring in

[1] Milchztg. 1883, 419; bull. 43, Chem. Div., U. S. Dept. of Agriculture, p. 191; Analyst, 1894, p. 76. See also Fleischmann and Wiegner, Jr. f. Ldw., 1913, pp. 283-328.

the mechanical condition of the nitrogenous components of the milk. The results obtained after a couple of hours will, as a rule, come about one degree higher than when the milk is cooled down directly after milking and its specific gravity then determined.

117. Influence of solid preservatives on lactometer readings. When potassium bi-chromate, corrosive sublimate, etc., is added to milk samples to preserve them from souring (190), the specific gravity of the milk will be increased; with the quantity usually added (½ gram to a pint of milk) the increase amounts to about 1 lactometer degree, and this correction of lactometer readings should be made with milk samples preserved in this manner. To avoid this error, Dr. Eichloff[1] recommends the use of a solution of potassium bichromate in water (43 grams to 1 liter), the specific gravity of which is 1.032, or similar to that of average milk; 5 cc. of this solution is required for a pint of milk. No correction is necessary for the dilution with this small amount of liquid preservative, or when a few drops of formaldehyd are used as a preservative.

118. Cleaning the lactometer. The lactometer should be cleaned directly after using, by rinsing with cold water; it is then wiped dry with a clean cloth and placed in the case.

118a. Testing the accuracy of lactometers. The correctness of lactometers may be determined with a fair degree of accuracy by placing them in different salt solutions prepared by dissolving exactly 3, 4, and 5 grams of *pure* dairy salt in 100 grams (cc.) of water. The specific gravities at 60° F. of solutions thus ob-

[1] Technik der Milchfrüfung, p. 98.

tained are 1.022, 1.029, and 1.036, for 3, 4, and 5 per cent. solutions, respectively.

Calculation of Milk Solids.

119. A number of chemists have prepared formulas for the calculation of milk solids when the fat content and the specific gravity (lactometer reading) of the milk are known. By careful work with milk tester and lactometer it is possible by means of these formulas to determine the composition of samples of milk with considerable accuracy, both outside of and in chemical laboratories. As the complete formulas given by various chemists (Behrend and Morgen, Clausnitzer and Mayer, Fleischmann, Hehner and Richmond, Richmond, Babcock)[1] are very involved, and require rather lengthy calculations, tables facilitating the figuring have been prepared. The formulas in use at the present time, in this country and abroad, are those proposed by Fleischmann, Hehner and Richmond, or Babcock. Babcock's formula is the one generally taught in American dairy schools and is therefore given here; it forms the foundation for Table VI in the Appendix for the calculation of solids not fat.

By the use of these tables the percents of solids not fat may be found, corresponding to lactometer readings from 26 to 36, and to fat contents from 0 to 6 per cent. The formula, as amended in 1895,[2] is as follows, S being the specific gravity and f the per cent. of fat in the milk.

$$\text{Solids not fats} = \left(\frac{100\,S - Sf}{100 - 1.0753\,Sf} - 1\right)(100 - f)2.5$$

[1] Agricultural Science, vol. III, p. 139.

[2] Wisconsin experiment station, twelfth report, page 120.

The derivation of this formula is explained in the report referred to.

120. Short formulas. The tables made up from this formula, giving the percentages of solids not fat corresponding to certain per cents. of fat and lactometer readings, are given in the *Appendix*. A careful examination of the tables will disclose the fact that the per cent. of solids not fat increases uniformly at the rate of .25, or one-fourth of a per cent. for each lactometer degree, and .02 per cent. for each tenth of a per cent. of fat. This relation is expressed by the following simple formulas:

$$\text{Solids not fat} = \tfrac{1}{4}\,L + .2\,f$$
$$\text{Total solids} = \tfrac{1}{4}\,L + 1.2\,f,$$

L being the lactometer reading at 60° F. (specific gravity $\times 1000 - 1000$), and *f* the per cent. of fat in the milk.

Rule: a, *To find the per cent. of solids not fat in milk, add two-tenths of the per cent. of fat to one-fourth of the lactometer reading,* and

b, *To find the per cent. of total solids in milk, add one and two-tenths times the per cent. of fat to one-fourth of the lactometer reading.*

These formulas and rules are easily remembered and can be quickly applied without the use of tables. The results obtained by using them do not differ more than .04 per cent. from those of the complete formula for milks containing up to 6 per cent. of fat, and may be safely applied in practical work.

The English dairy chemist Droop Richmond has constructed an ingenious sliding "milk scale" which enables one to readily find the percentages of total solids

corresponding to different lactometer readings and fat contents, or the percentage of fat from total solids and lactometer readings.[1]

Adulteration of Milk.

121. Methods of adulteration. The problem of determining whether or not a sample of milk is adulterated becomes an important one in the work of milk inspectors and food chemists. Managers of creameries and cheese factories are also sometimes interested in ascertaining possible adulterations in the case of some patron's milk, although since the general introduction of the Babcock test in factories and the payment for the milk on the basis of the amount of butter fat delivered, the temptation to water or skim the milk has been largely removed. In the city milk trade, especially in our larger cities, watered or skimmed milk is occasionally met with, in spite of the vigilance of their milk inspectors or the officers of the city boards of health.

When the origin of a suspected sample of milk is known, a second sample should always be taken on the premises, if possible, by or in the presence of the inspector, and the composition of the two samples compared. If the suspected sample is considerably lower in fat content than the second, so-called *control-sample,* and has a normal or high per cent. of solids not fat, it is skimmed; if the fat and solids not fat are below normal, it is watered; and if both these percentages are abnormally low, the sample is most likely both watered and skimmed (126).

1 Dairy Chemistry, p. 69 (second ed.)

122. Latitude of variation. In order to determine whether or not a sample of milk is skimmed or watered, or both skimmed and watered, the per cents. of fat and of solids not fat in the sample must be ascertained, and if a control-sample can be secured, these determinations for both samples compared. The proper latitude to be allowed for the natural variation in the composition of milk differs according to the origin of the milk; in case of milk from single cows, the variations in fat content from day to day may exceed one per cent., although under ordinary conditions the per cent. of fat in most cow's milk will not vary that much. The content of solids not fat is more constant, and rarely varies one-half of one per cent. from day to day with single cows. Cows in heat or sick cows may give milk differing considerably in composition from normal milk.[1]

123. Mixed herd milk is of comparatively uniform composition on consecutive days, and as most milk offered for sale or delivered to factories is of this kind, the task of the milk inspector is made considerably easier and more certain on this account. Daily variations in herd milk beyond one per cent. of fat and one-half per cent. of solids not fat, are suspicious and may be taken as fairly conclusive evidence of adulteration. This is especially true in case the control-sample shows a comparatively low content of fat or solids not fat (159).

124. Legal standards. Where a control-sample cannot be taken, the legal standards of the various states for fat or solids in milk are used as a basis for calculat-

[1] Blythe, Foods, their Composition and Analysis, London, 1903 p. 250 et seq.

ing the extent of adulteration of a sample of milk. A list of legal standards for milk in this country and abroad is given in the *Appendix*. These standards determine the limits below which the milk offered for sale within the respective states must not fall. Legally it matters not whether a sample of milk offered for sale has been skimmed or watered by the dealer or by the cow; in the latter case, the cows producing the milk are of a breed or a strain that has been bred persistently for quantity of milk, without regard to its quality. In most states the legal standard for the fat content of milk is 3 per cent., and for solids not fat 9 per cent. There are, however, cows which at times produce milk containing only 2.5 to 2.8 per cent. of fat, and less than 8.5 per cent. solids not fat. Such milk cannot therefore be legally sold in most states in the Union, and the farmer offering such milk for sale, even if he does not know the composition of the milk produced by his cows is liable to prosecution just as if he had directly watered the milk. By mixing the milk of several cows, the chances are that the mixed milk will contain more fat and solids not fat than called for by the legal standard; if such should not be the case, cows producing richer milk must be added to the herd so as to raise the quality of the herd milk up to the legal standard, or the cows giving very thin milk must be disposed of.

125. The specific gravity of the milk solids. A calculation of the specific gravity of the milk solids is of considerable assistance in interpreting the results of analyses of suspected milk samples. The milk solids vary but slightly in specific gravity, viz., between 1.25 and 1.34, the richer milks having sol-

ids of low specific gravities. The specific gravity of the milk solids is calculated by means of Fleischmann's formula

$$S = \frac{t}{100\,s - 100}$$
$$t - \frac{}{s}$$

S being the sp. gr. of the milk solids, *s* that of the milk and *t* the total solids of the milk.

Example: A sample of milk has been found to contain 13.0 per cent. of solids, sp. gr. 1.032; then $\frac{100\times1.032-100}{1.032} = 3.101$; $13.0 - 3.101 = 9.899$; $\frac{13.0}{9.899} = 1.31$, the specific gravity of the milk solids.

The specific gravity of the solids does not change if the milk is watered, while it is increased when the milk is skimmed. If a sample of milk of the composition given in the preceding example had been watered so as to reduce the solids to 11.7 per cent and the specific gravity to 1.0291 (as would be the case when 10 per cent. of water was added), we would again have, by calculation as above, S=1.31. If, on the other hand, the milk was skimmed so as to reduce the solids to 11.7 per cent., thereby increasing the specific gravity of the milk to, say 1.035, we would have by substituting these values in the preceding formula, S=1.41, showing conclusively that the milk had been skimmed.

An addition of skim milk to whole milk would have the same effect as skimming, as regards the composition of the latter, and the specific gravity of its solids.

The specific gravity of pure butter fat at 60° F. is .93, and of the fat-free milk solids, 1.5847 (Fleischmann). The solids of skim milk have a specific gravity of 1.56. Samples of whole milk, the solids of which have a specific gravity above 1.34 are suspicious, and a specific gravity over 1.40 is conclusive evidence of skimming.

To facilitate the calculation of the specific gravity of milk solids, Table IV is given in the *Appendix,* showing at a glance the value of $\frac{100s-100}{s}$ for specific gravities between 1.019 and 1.0369. An example will readily illustrate the use of the table.

Example: A sample of milk has a specific gravity of 1.0343 and contains 12.25 per cent. solids. In Table IV, we find in the

horizontal line beginning with 1.034 under the column headed 0.00 3, the figure 3.316, which is the value for $\frac{100s-100}{s}$ when s=1 0343. Introducing this value and that of the total solids in the formula, the calculation is 12.25—3.316=8.934; 12.25÷8.934=1.37, which is the specific gravity of the solids in this case.

126. **To recapitulate.** Adulteration of milk by watering or skimming, or both, may be established by a comparison of the composition of the suspected sample with that of a control-sample, or if none such can be obtained, with the legal standards. If the composition of the two samples varies appreciably, the milk has been adulterated, and the character of the adulteration is shown from the following statement:

If the analysis of the suspected sample shows		*the milk is*
sp. gr. of milk	low	watered
fat and solids not fat	low	watered
sp. gr. of solids	normal	watered
sp. gr. of milk and of solids	high	skimmed
solids not fat	high	skimmed
fat and solids	low	skimmed
sp. gr. of milk	normal	watered and skimmed
sp. gr. of solids	normal or high	watered and skimmed
fat and solids not fat	low	watered and skimmed

The extent of the adulteration is determined as given below.

127. **Calculation of extent of adulteration.**[1] In the following formulas, percentages found in the control-samples, if such are at hand, are always substituted for the legal standards.

a. *Skimming.*—1. If a sample of milk has been skimmed, the following formula will give the number of pounds of fat abstracted from 100 lbs. of milk:

[1] Woll, Handbook for Farmers and Dairymen, New York, 1907, pp. 267–8.

Fat abstracted=legal standard for fat—f, . . (I)
f being the per cent. of fat in the suspected sample.

2. The following formula will give the per cent. of fat abstracted, calculated on the total quantity of fat originally found in the milk:

$$x=100-\frac{f\times 100}{\text{legal standard for fat}} \quad - - - - - - \text{(II)}$$

b. *Watering.*—If a sample is watered, the calculation is most conveniently based on the percentage of solids not fat in the milk. The percentage adulteration may be expressed either on basis of the amount of water present in the adulterated milk, or the amount of water added to the original milk:

1. Per cent. of foreign (*extraneous*) water in the *adulterated milk*

$$=100-\frac{S\times 100}{\text{legal standard for solids not fat}} \text{(III)}$$

S being the per cent. of solids not fat in the suspected sample.

Example: A sample of milk contains 7.5 per cent. solids not fat; if the legal standard for solids not fat is 9 per cent., then $100-\frac{7.5\times 100}{9}=16.7$, shows the per cent. of extraneous water in the milk.

2. Watering of milk may also be expressed in per cent. of water *added to the original milk,* by formula IV:

Per cent. of water *added to the original milk*

$$=\frac{100\times \text{leg. stand. for sol. not fat}}{S}-100 \quad \text{(IV)}$$

In the example given above, $\frac{100\times 9}{7.5}-100=20$ per cent. of water was added to the original milk.

c. *Watering and skimming.*—If a sample has been both watered and skimmed, the extent of watering is

ascertained by means of formula (III) or (IV), and the fat abstracted found according to the following formula:

Per cent. fat abstracted=

$$\text{leg. stand. for fat} - \frac{\text{leg. stand. for sol. not fat}}{S} \times f. \quad \text{(V)}$$

Example: A sample of milk contains 2.4 per cent. of fat and 8.1 per cent. solids not fat; then

Extraneous water in milk=$100 - \frac{8.1 \times 100}{9} = 10$ per cent.

Fat abstracted=$3 - \frac{9 \times 2.4}{8.1} = .33$ per cent, or 11 per cent of total fat in milk.

100 lbs. of the milk contained 10 lbs. of extraneous water and .33 lb. of fat had been skimmed from it.

For methods of detection of other adulterations and of preservatives in dairy products, see Chap. X, 299, *et seq.*

Questions.

1. What is the weight of 1000 cc. of (a) water; (b) skim milk; (c) whole milk; (d) cream testing 30% fat; (e) whey; (f) butter fat?

2. If the sp. gr. of a sample of milk is 1.0325 at 68° F., what is the lactometer reading at 60°?

3. What effect on the sp. gr. has 1.0% solids not fat and 1.0% fat?

4. How can the accuracy of a lactometer be determined?

5. If a sample of milk has a sp. gr. of 1.032 and 13.0% solids, what is the sp. gr. of the milk solids?

6. How can (a) skimmed milk, (b) watered milk, (c) skimmed and watered milk be detected?

7. Give lactometer readings and percentages of fat in samples showing (a) watering, (b) skimming, (c) watering and skimming.

8. If one quart of water is added to one quart of milk, what per cent. of water is added, and what per cent. extraneous water does the mixture contain?

9. How many pounds of fat have been removed from 100 pounds of a sample of milk testing 2.6%, and what per cent. of the fat was removed?

10. If a sample of milk contains 7.0% solids not fat, what per cent. water was added and how much extraneous water did the sample contain?

11. What has probably been done to each of the following samples of milk, that were found to contain (a) 7.2 per cent. solids not fat, 2.6 per cent. fat; (b) 9.0 per cent. solids not fat, 2.5 per cent. fat; (c) 6.5 per cent. solids not fat, 2.4% fat?

12. What is the per cent. solids not fat and what is the condition of each of the following samples of milk:

	Lactometer Reading.	*Per Cent Fat.*
(a)	32.0 at 58° F.	4.0
(b)	33.5 at 56° F.	2.5
(c)	30.0 at 63° F.	3.5
(d)	28.0 at 54° F.	2.5
(e)	27.4 at 69° F.	2.4

CHAPTER VII.

TESTING THE ACIDITY OF MILK AND CREAM.

128. Cause of acidity in milk. Even directly after milk is drawn from the udder it will be found to have an acid reaction, when phenolphtalein is used as an indicator.[1] The acidity of fresh milk is not due to the presence of free organic acids in the milk, like lactic or citric acid, but to acid phosphates, and possibly also in part to free carbonic acid gas in the milk or to the acid reaction of casein. Even in case of so-called sweet milk, the amount of acidity found in milk fresh from the cow or nearly so is on the average about .07 per cent. When the milk is received at the factory it will rarely test less than .10 per cent. of acid, calculated as lactid acid; some patrons bring milk day after day that does not test over .15 per cent. of acid; that of others tests from .20 to .25 per cent., and some lots, although very rarely, will test as high as .3 of one per cent. of acid. It has been found that milk will not usually smell or taste sour or "turned," until it contains .30 to .35 per cent. of acid.

129. The acidity in excess of that found normally in milk as drawn from the udder, is due to other causes than those described. Bacteriological examinations of milk from different sources and of milk of the same origin at different times have shown that there is, roughly speaking, a direct relation between the bacteria found

[1] Freshly drawn milk shows an *amphoteric* reaction to litmus, i. e., it colors blue litmus paper red, and red litmus paper faintly blue.

in normal milk, and its acidity; the larger the number of bacteria per unit of milk, the higher is, in general, the acidity of the milk. The increase in the acidity of milk on standing is caused by the breaking down of milk sugar into lactic acid through the activities of acid-forming bacteria. Since the bacteria get into the milk through a lack of cleanliness during the milking, or careless handling of the milk after the milking, or both, it follows that an acidity test of new milk will give a good clue to the care bestowed in handling the milk. Such tests will show which patrons take good care of their milk and which do not wash their cans clean, or their hands and the udders of the cows before milking, and have, in general, dirty ways in milking and caring for the milk. The acidity test is always higher in summer than in winter, and is generally high in the case of milk kept for more than a day (Monday milk), or delivered after a warm, sultry day or night. The bacteria have had a good chance to multiply greatly in such milk, even if it be kept cooled down to 40°-50° F., and as a result considerable quantities of lactic acid have been formed. The determination of the acidity of fresh milk is explained in detail below (147).

130. Method of testing acidity. Methods of measuring the acidity or alkalinity of liquids by means of certain chemicals giving characteristic color reactions in the presence of acid or alkaline solutions (so-called *volumetric* methods of analysis) have been in use for many years in chemical laboratories. They were applied to milk as early as 1872 by Soxhlet,[1] and the method

[1] Jour. f. prakt. Chemie, 1872, p. 6, 19.

worked out by Soxhlet an dHenkel has since been in general use by chemists. They measured out 50 cc. of milk to which was added 2 cc. of a 2 per cent. alcoholic solution of phenolphtalein, and this was titrated with a one-fourth normal soda solution[1] (see below). In this country, Dr. A. G. Manns in 1890 published the results of work done in the line of testing the acidity of milk and cream,[2] and the method of procedure and apparatus proposed by him has become known under the name of *Manns' test,* and is being advertised as such by dealers in dairy supplies.

131. Manns' test. The acid in milk or cream is measured by using an alkali solution of a certain strength, with an indicator which shows by a change of color in the milk when all its acid has been neutralized. Any of the alkalies, soda, potash, ammonia, or lime can be used for making the standard solution, but it requires the skill and apparatus of a chemist to prepare it of the proper strength. A tenth-normal solution[3] of caustic soda is the alkali solution used most frequently in de-

[1] Fleischmann, Lehrb. d. Milchwirtschaft, 3rd ed., p. 57.

[2] Illinois experiment station, bulletin 9.

[3] *Normal solutions,* as a general rule, are prepared so that one liter shall contain the hydrogen equivalent of the active reagent weighed in grams (Sutton). Caustic soda (NaOH) is made up of an atom each of sodium (Na), oxygen (O), and hydrogen (H); its molecular weight is therefore

$$23+16+1=40$$
$$Na\ O\ H$$

A normal soda solution then is made by dissolving 40 grams of soda in water, making up the volume to 1000 cc.: a one-tenth normal solution will contain one-tenth of this amount of soda, or 4 grams dissolved in one liter. One cubic centimeter of the latter solution will contain .004 gram of soda, and will neutralize .009 gram of lactic acid. The formula for lactic acid is $C_3H_6O_3$ (see p. 16), and its molecular weight is therefore $3\times12+6\times1+3\times16=90$. A tenth-normal solution of lactic acid contains 9 grams per liter, and .009 gram per cubic centimeter.

termining the acidity of milk, and is the solution labeled *Neutralizer* of the Manns' test.

The indicator used is a solution of *phenolphtalein,* a light yellowish powder; its compounds with alkalies are red, in weak alkaline solutions pink colored, while its acid compounds are colorless. The phenolphtalein solution used is prepared by dissolving 10 grams in 300 cc of 90 per cent. alcohol (Mohr).

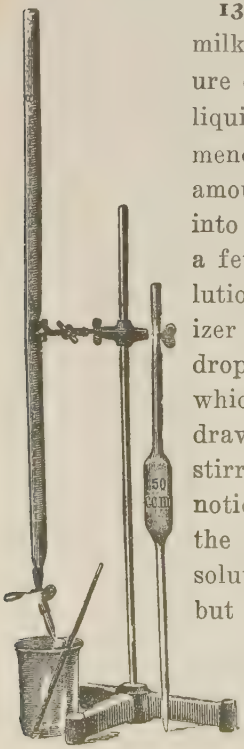

FIG. 41. Apparatus used in Manns' test.

132. In testing the acidity of either milk or cream it is necessary to measure out with exactness the quantity of liquid to be tested; Manns recommended using a 50 cc. pipette. This amount of milk or cream is measured into a clean tin, porcelain or glass cup, a few drops of the phenolphtalein solution are added, and the Neutralizer (or alkali solution) is cautiously dropped in from a burette, the point at which the solution stands before any is drawn off being noted. By constant stirring during this operation it will be noticed that the pink color formed by the addition of even a drop of alkali solution will at first entirely disappear, but as more and more of the acid in the sample becomes neutralized, the color will disappear more slowly, until finally a point is reached when the pink color remains permanent for a time. No

more alkali should be added after the first appearance of a uniform pink color in the sample. This color will fade and gradually disappear again on standing, owing to the effect of the carbonic acid of the air, to which phenolphtalein is very sensitive. The amount of the alkali solution used for the test is then obtained from the reading on the scale of the burette. The per cent. of acid in the sample is calculated by multiplying the number of cc. of alkali solution used, by .009 and dividing the product by the number of cc. of the sample tested, the quotient being multiplied by 100.

$$\text{Per cent. acidity} = \frac{\text{c. c alkali} \times .009}{\text{c. c. sample tested}} \times 100$$

If 50 cc. of cream required 32 cc. of alkali solution to produce a permanent pink color, the per cent. of acid in the cream would be $\frac{32 \times .009}{50} \times 100 = .58$ per cent. A part of this calculation may be saved by using a factor for multiplying the number of cc. of alkali added in each test. This factor is obtained by dividing .009 (the number of grams of lactic acid neutralized by one cc. of alkali solution) by the number of cc. of sample tested, and multiplying the quotient by 100. If a 50 cc. pipette is used for measuring the sample to be tested, the factor will be $(.009 \div 50) \times 100 = .018$; if a 25 cc. pipette is used, the factor will be $(.009 \div 25) \times 100 = .036$; and if a 20 cc. pipette is used, $(.009 \div 20) \times 100 = .045$ will be the factor to be applied in calculating the per cent. of acidity, the number of cc. of alkali used being in all cases multiplied by the particular factor corresponding to the volume of the sample tested.

133. If a Babcock milk test pipette is used for measuring the milk or cream to be tested for acidity, the factor will be $(.009 \div 17.6) \times 100 = .051$. This is so nearly .05 that sufficiently accurate results may be obtained by simply dividing the number of cc. used by two; the result will be the tenths of per cent. of acid in the sample tested, e. g., if 17.6 cc. of cream required 12 cc. of one-tenth normal alkali to give a pink color, then the per cent. of acid is $12 \div 2 = .6$ per cent. If one-fifth normal alkali is used for testing, the per cent. of acidity is shown directly by the number of cc. used (Vivian).[1]

134. Manns' testing outfit The apparatus (see fig. 41) and chemicals necessary for testing the acidity of milk or cream by the so-called Manns' test include one gallon of a one-tenth normal alkali solution; four ounces of an alcoholic solution of phenolphtalein, a 50 cc. glass burette provided with a pinch-cock, a burette stand and a pipette for measuring the sample. This outfit will make about 100 tests and is sold for $5.00.[2]

135. The alkaline tablet test. Solid alkaline tablets were proposed by Farrington in 1894, as a substitute for the liquid used in Manns' test.[3] It was found possible to mix a solid alkali carbonate and coloring matter, and compress the mixture into a small tablet, which would contain an exact amount of alkali. The advantage of the tablets lies in the fact that they

[1] Van Norman recommends the use of a 50th normal solution for testing cream (see Purdue exp. sta., bull 104). 37 cc. of a normal soda solution is diluted to 1850 cc. in a two-quart bottle, such as is used for mineral waters. Each cc. of this solution represents .01 cc. of acidity when 17.6 cc. of cream is measured off. The titration is made in the usual manner, using phenolphtalein as an indicator. See also Cornell Univ. circ. No. 7.

[2] *Derarda's acidimeter* (Milchzeitung 1896, p. 785) is based on the same principle as Manns' test: one-tenth soda solution is added to 100 cc. of milk in a glass-stoppered granulated flask, 2 cc. of a 4 per cent. phenolphtalein solution being used as an indicator. The graduations on the neck of the flask give the "degrees acidity" directly.

[3] Illinois experiment station, bulletin 32, April, 1894.

will keep far better than a standard alkali solution, and they can be safely sent by mail; they also require less apparatus and are considerably cheaper than standard alkali solutions; 1000 of these tablets, costing $2.00, will make about 400 tests.[1] Similar alkaline tablets were placed on the market in Europe at about the same time, viz., Stokes' *Acidity Pellets* in 1893, and Eichler's *Säurepillen* (acid pills) in 1895.[2]

Two methods of using the tablets have been proposed, one, for the titration (determination of acidity) of ripening cream in the manufacture of sour-cream butter; and the other, for determining the approximate acidity of different lots of apparently sweet milk or cream.

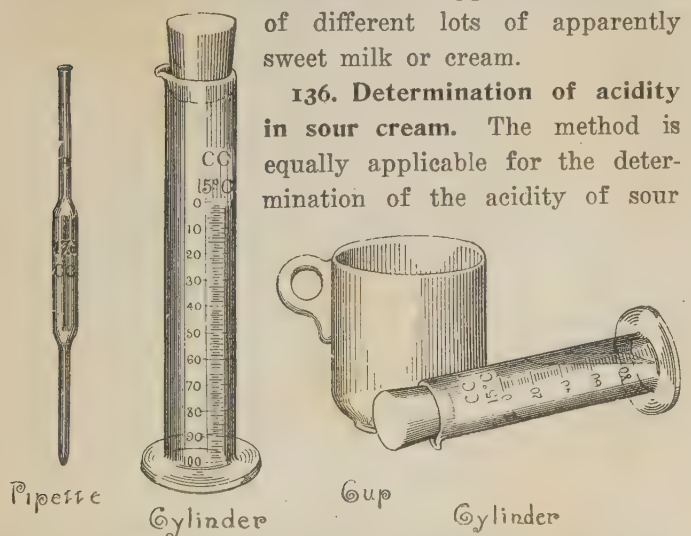

FIG. 42. Apparatus used for determining the acidity of cream or milk.

136. Determination of acidity in sour cream. The method is equally applicable for the determination of the acidity of sour cream, sour milk and buttermilk, but is most frequently employed in testing the acidity of cream, to examine

[1] The tablets are sold by dealers in dairy supplies.

[2] Milchzeitung, 1895, pp. 513–16.

whether or not the ripening process has reached the proper stage for churning the cream. The apparatus used (see fig. 42) is as follows:

1 17.6 cc. pipette.

1 white cup.

100 cc. graduated cylinders; it is well to provide two or three of these, although only one is strictly necessary.

137. Preparation of the solution. The tablet solution formerly used was prepared by dissolving five tablets in 50 cc. of water; with 20 cc. of cream each cubic centimeter of this solution represents .017 per cent. of acid (lactic acid) in the sample tested. The amount of acid in a given sample is then obtained by multiplying the number of cubic centimeters of the tablet solution used, by .017.

138. According to a suggestion made by Mr. C. L. Fitch,[1] the strength of the solution was changed in such a manner that the percentages of acidity are indicated directly by the number of cubic centimeters of tablet solution used in each test.

The 17.6 cc. pipette may be used for measuring the sample for acidity testing, and the results read directly from the graduated cylinder, if the tablet solution is prepared by taking one tablet for every 19.5 cc. of water; five tablets are therefore dissolved in 97 cc. of water.

139. As cream during its ripening process under the conditions present in this country generally has from .5 to .6 per cent. of acid before it is ready to be churned,

[1] Hoard's Dairyman, Sept. 3, 1897.

a 50 cc. cylinderful of tablet solution of this strength will not be sufficient to make a test of cream containing over .5 per cent. of acid, although it is enough for testing the cream up to this point during the ripening process. The acid-testing outfit should therefore contain a 100 cc. graduated cylinder, instead of one of 50 cc. capacity, so that cream of any amount of acidity up to 1 per cent. can be tested. A tablet solution of the strength given has not only the advantage over the solution previously recommended (5 tablets to 50 cc. of water)[1] of showing the per cent. of acidity directly, without tables or calculations, but being weaker, the unavoidable errors of determination are decreased by its use.

Since a 17.6 cc. pipette is found in creameries and dairies with the Babcock test outfit, no new apparatus is necessary for making the acidity test in the manner given.

140. The preparation of the standard solution is as follows: Five tablets are placed in the 100 cc. cylinder which is filled to the 97 cc. mark with clean soft water.[2] The cylinder is tightly corked, shaken and laid on its side, as the tablets dissolve more quickly when the cylinder is placed in this position than when left upright with the tablets at the bottom. Several cylinders containing the tablet solution may be prepared at a time; as soon as one is emptied, tablets and water are again added, and the cylinder is corked and placed in a hori-

[1] Illinois experiment station, bulletin 32; Wisconsin experiment station, bulletin 52.

[2] Condensed steam or rain water should be used, and not hard or alkali water, since the impurities in these affect the strength of the tablet solution.

zontal position. In this way fresh solutions ready for testing are always at hand. The cylinder is kept tightly corked while the tablets are dissolving, so that none of the liquid is lost by the shaking. It is well to put the tablets in the cylinder with water at night; the solution will then be ready for use in the morning. Excepting a flocculent residue of inert matter, "settlings," which will not dissolve, the tablets must all disappear in the solution before this is used. The strength of the tablet solution does not change perceptibly by standing, at least for one week. The only precaution necessary is to avoid evaporation of the solution by keeping the cylinders tightly corked. The solid tablets will not change if kept dry, any more than dry salt changes by age.

141. Accuracy of the tablets. The tablets have been repeatedly tested by chemists and found to be accurate and uniform in composition. Tests made with the tablets according to the directions here given can therefore be relied on as correct. The alkali solution is very sensitive, however, and should not be measured in a cylinder which has been previously used for measuring sulfuric acid, as the smallest drop or film of acid from a dish or from the operator's fingers will change the strength of the standard tablet solution.

141a. Powdered sodium carbonate weighed out in the exact quantity required for making a gallon of tenth normal solution has of late been placed on the market; these "test powders" are cheaper than alkaline tablets and when put out by a reliable firm may be depended upon to be accurate.

142. Making the acidity test. The cream to be tested is thoroughly mixed, and 17.6 cc. are measured into the cup. The pipette is rinsed once with water, and the rinsings added to the cream in the cup. A few cc. of the tablet solution prepared as given above are now poured from the cylinder into the cream and mixed thoroughly with it by giving the cup a gentle rotary motion. The tablet solution is added in small quantities until a permanent pink color appears in the sample. The number of cc. of tablet solution which has been used to color the cream is now read off on the scale of the cylinder.

In comparing the results of one test with another, the same shade of color should always be adopted.[1] The most delicate point is the first change from pure white or cream color to a uniform pink which the sample shows when the acid contained therein has been neutralized. This shade of color is easily recognized with a little practice. The pink color is not permanent unless a large excess of the alkaline solution has been added, on account of the influence of the carbonic acid of the air (132), and the operator should not therefore be led to believe by the reappearance of the white color after a time, that the point of neutralization was not already reached when the first uniform shade of pink was observed.

143. Acidity of cream. 17.6 cc. of sweet cream is

[1] A helpful suggestion has been made by the Danish State Dairy Instructor, Dr. G. Ellbrecht, for obtaining a uniform color in acidity tests. Small strips of pink paper are moistened and attached to the cup or glass in which the titration is made, and alkali solution is added, until the color of the milk or cream corresponds to that of the strips.

generally neutralized by 15 to 20 cc. of this tablet solution, representing from .15 to .20 per cent. of acid. A mildly sour cream is colored by 35 cc. tablet solution, and a sour cream ready for churning by about 50 to 60 cc. tablet solution. As the cream ripens, its acidity increases. The rate of ripening depends largely on the temperature at which the cream is kept. Cream containing .5 to .6 per cent. of acid will make such butter as the general American market demands at the present time Cream showing an acid test of .55 per cent. may not be too sour, but .65 per cent. of acid is very near, if not on the danger line, since such cream is likely to make strong flavored, almost rancid butter Each lot of cream should be tested as soon as it is ready for ripening, and the result of the test will show whether the cream should be warmed or cooled in order to have it ready for churning at the time desired. Later tests will show the rate at which the ripening is progressing, and the time when the cream has reached the proper acidity for churning.

144. The influence of the richness of cream on the acid test has been studied by Professor Spillman,[1] and others.[2] Since the acidity develops in the cream serum. it follows that an acidity of, say .5 per cent. in a 40 per cent. cream represents a larger acidity than in 20 per cent. of cream, e. g.; in the former case we have .5 gram of acid in 60 grams of serum (=.83 per cent. of the serum); in the latter case .5 gram acid is found in 80 grams serum (=.63 per cent. of the serum). There-

[1] Washington experiment station, bulletin 32.
[2] Chicago Dairy Produce, April 21, 1900, p. 30; Iowa expt. sta., bul. 52.

fore, rich cream need not be ripened to as high a degree of acidity as thin cream. A table is given in the Iowa bulletin referred to, showing the relation between the richness and the acidity of cream.

145. Spillman's cylinder. The graduated cylinder shown in fig. 43 was devised by Professor Spillman for use in testing the acidity of milk and cream with Farrington's alkaline tablets. The following directions are given for making tests with this piece of apparatus:[1]

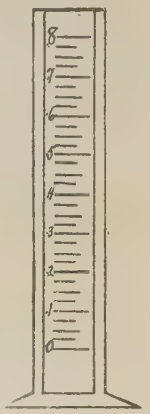

FIG. 43. Spillman's cylinder, used in determining the acidity of cream or milk.

"All that is needed in addition to the acid-test graduate shown in the accompanying illustration, is a common prescription bottle of six or eight ounce capacity, and a package of Farrington's alkaline tablets. Fill the bottle with water and add one tablet for each ounce of water in the bottle. Shake the bottle frequently to aid in dissolving the tablets.

"*Making the test.* In making the test, the acid-test graduate is filled to the zero mark with the milk or cream to be tested. The tablet solution is then added, a little at a time, and the graduate shaken after each addition, in order to thoroughly mix the milk and the tablet solution. In shaking the graduate, give it a rotary motion to prevent spilling any of the liquid. Continue adding the tablet solution until a permanent pink color can be detected in the milk. The level of the liquid in the graduate, measured by the scale on the graduate, will then show the per cent. of the acidity of the milk. It is best to stand the graduate on a piece of white paper, so that the first pink coloration of the milk may be easily detected."

146. The Marschall acid test (see fig. 44) is a convenient apparatus for determining the acidity of milk, cream, or whey.[2] It is used with a tenth-normal alkaline

[1] Washington experiment station, bulletin 24.

[2] See Wis. exp. sta., bull. 129.

solution ("Neutralizer"), 9 cc. of milk, cream, etc., being measured out for the test, and alkali solution added from the combined burette and bottle, the former being graduated to two-tenths of one cc. The burette is filled by tipping the bottle and the surplus of the "neutralizer" will flow back, leaving the solution at the zero mark. With the quantity of milk given, the readings obtained represent per cent of acidity direct.

FIG. 44. The Marschall acid test.

147. Rapid estimation of the acidity of apparently sweet milk or cream. a, **Milk.** The alkaline tablet method offers a ready means of estimating the acidity of milk or cream that is still sweet to the taste. The selection of the best kinds of milk is especially important in pasteurizing milk or cream. As previously noted, milk which gives the highest acid test contains, as a rule, a larger number of bacteria and spores not destroyed by pasteurization than does milk giving a low acid test (129); the acidity test may therefore be used to advantage for the purpose of selecting milk best adapted for pasteurization,

as well as such as is to be retailed or used in the manufacture of high-grade butter and cheese.

In distinguishing milk fit for pasteurization purposes from that which is doubtful, an arbitrary standard of two-tenths of one per cent. of acid may be taken as the

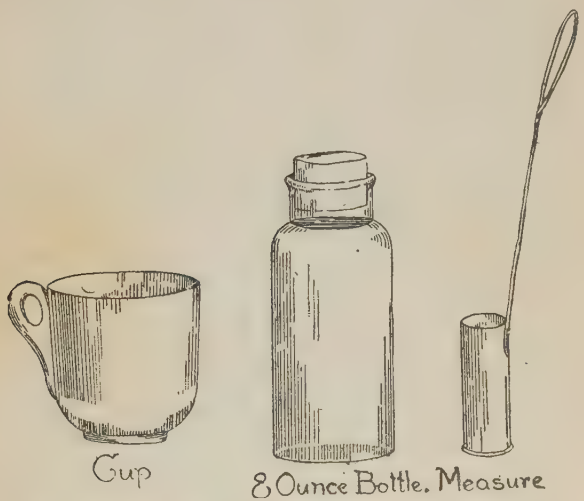

FIG. 45. Apparatus used for rapid estimation of the acidity of apparently sweet milk or cream.

upper limit for milk of the former kind. The apparatus used in making this test is shown in the accompanying illustration (fig. 45), and consists of a white teacup; a four-, six-, or eight-ounce bottle, and a No. 10 brass cartridge shell, or a similar measure. A solution of the tablets in water is first prepared, one tablet being always added to each ounce of water: four tablets in a four-ounce bottle; six, in a six-ounce bottle, etc., the amount of tablet solution prepared depending on the

number of tests to be made at a time. The bottle is filled up to its neck with clean, soft water, and the solution prepared in the manner previously given (140).

148. Operating the test. As each lot of milk is brought to the creamery in the morning and poured into the weigh can, a cartridge-shell dipper is filled with milk and this is poured into the white cup. The same or another No. 10 shell is now filled twice with the tablet solution and emptied into the milk in the cup. Instead of dipping twice with one measure or a No. 10 shell, a tin measure can be made holding as much as two No. 10 shells, or the tablet solution may be made of double strength; that is, two tablets to each ounce of water and the same sized measure used for both the milk and the tablet solution. The liquids are then mixed in the cup by giving this a quick, rotary motion, and the color of the mixture noticed. If the milk remains white it contains more than two-tenths of one per cent. of acid and should not be used for pasteurization. If it is colored after having been thoroughly mixed with two measures of tablet solution, it contains less than this amount of acid and may, as far as acidity goes, be safely used for pasteurization or for any other purpose which requires thoroughly sweet milk. The shade of color obtained will vary with different lots of milk; the sweetest milk will be most highly colored, but a milk retaining even a faint pink color with two measures of tablet solution, or one measure of the double strength solution to one measure of milk, contains less than .2 per cent. of acid.

By proceeding in the manner described, the man receiving and inspecting the milk at the weigh-can is able to test the acidity of the milk delivered nearly as quickly as he can weigh it; and according to the results of the test he can send the milk to the general delivery vat or to the pasteurization vat, as the weigh-can may be provided with two conductor spouts.

149. Size of measure necessary. It is not necessary to use a No. 10 shell for a measure in working the preceding method; one of any convenient size that can be filled accurately and quickly, will answer the purpose equally well, if a measure of the same size is used for both the sample and the tablet solution. Each measureful of tablet solution made up as directed, will in this case represent one-tenth per cent. of acid in the sample tested.[1]

150. b, Cream. Cream can be tested in the way already described for testing the acidity of fresh milk, by adding to one measureful of cream in the cup as many measures of tablet solution as are necessary to change the color of the cream when the two liquids are thoroughly mixed. If one measure of tablet solution colors one measure of cream, this contains less than .1 per cent. acid; if five measures of tablet solution are required, the cream contains about .5 per cent. acid, etc. By proceeding in the manner described, the operator can estimate the acidity to within .05 per cent. of acid, if half measures of tablet solution are added. The re-

[1] In European creameries and city milk depots the *alcohol test* is often applied to every can of milk received; milk that is sufficiently sour to be noticed by the taste, will coagulate when mixed with an equal volume of 70% alcohol.

sults thus obtained are sufficiently delicate for all practical purposes.

151. Detection of boracic acid preservatives in milk. The application of the alkaline tablet test for detecting the boracic acid in milk was first discussed in bulletin No. 52 of Wisconsin experiment station. The acidity of the milk is increased by the addition of boracic acid, but neither the odor nor the taste of the milk is affected thereby. By adding to sweet milk the amount of boracic acid which will keep it sweet 36 hours, its acidity may be increased to .35 per cent., in a sample of milk which previously tested perhaps only .15 per cent. acid.

As before stated, unadulterated milk will usually smell or taste sour or "turned," when it contains .30 to .35 per cent. acid (121); milk testing as high as this limit, which neither smells nor tastes sour in any way, is therefore in all probability adulterated with some preparation containing boracic acid or a similar compound.

152. "Alkaline tabs." These are not the alkaline tablets, but a substitute which was put on the market by a New York firm. The outfit furnished consisted of four packages of paper discs made of heavy filter paper, each of about the size of an old-style copper cent; two packages of square paper; one glass of about 10 cc. capacity, and one small glass bottle. An investigation of these "Tabs" soon disclosed the fact that they were entirely inaccurate, and that no dependence could therefore be placed on the results obtained by their use.

Questions.

1. If 20 cc. cream require 12 cc. $\frac{N}{10}$ alkali for neutralization, what per cent. acid in the sample?

2. If 1 cc. $\frac{N}{10}$ alkali neutralize .009 gram lactic acid, what is the per cent. of acid in a sample of cream, which required 12 cc. alkali for 25 cc. of cream?

3. What apparatus and strength of solution must be taken to show per cent. acidity directly from cc. alkali used with Farrington's alkaline tablets?

4. If cream testing 20% fat has an acidity of .6%, what will be the corresponding acidity of cream testing 40% fat?

CHAPTER VIII.

TESTING THE PURITY OF MILK.

153. The Wisconsin curd test. Cheese makers are often troubled with so-called floating or gassy curds which produce cheese defective in flavor and texture. These faults are usually caused by some particular lot of milk containing impurities that cannot be detected by ordinary means of inspection. The Wisconsin curd test is used to detect the source of these defects and thus enable the cheese maker to exclude the milk from the particular farm or cow to which the trouble is traced. This test is similar in principle to tests that have long been in use in cheese-making districts in Europe, notably in Switzerland,[1] but was worked out independently at the Wisconsin Dairy School in 1895 and is now generally known as the "Wisconsin Curd Test."[2]

154. Method of making the test. Pint glass jars, thoroughly cleaned and sterilized with live steam, are provided; they are plainly numbered or tagged, one jar being provided for each lot of milk to be tested. The jars are filled about two-thirds full with milk from the various sources; it is not necessary to take an exact

[1] Herz, Unters. d. Kuhmilch, Berlin, 1889, p. 87; Siats, Unters. landw. wicht. Stoffe, 1903, p. 140.

[2] Wisconsin experiment station, twelfth report, p. 148. The apparatus used for the test was greatly improved in 1898, and a description of the improved test is given in bulletin No. 67 and the annual report of the Station for 1898 (fifteenth report, pp. 47-53), from which source the accompanying illustration is taken (see fig. 46).

quantity; they are then placed in a water tank, the water of which is heated until the milk in the jars has a temperature of 98° F. In transferring the thermometer used from one jar to another, special care must be taken to clean it each time in order to prevent contamination of pure lots of milk by impure ones.

When the milk has reached a temperature of 98°, add to each sample ten drops of rennet extract, and mix by giving the jar a rotary motion. The milk is thus curdled, and the curd allowed to stand for about twenty

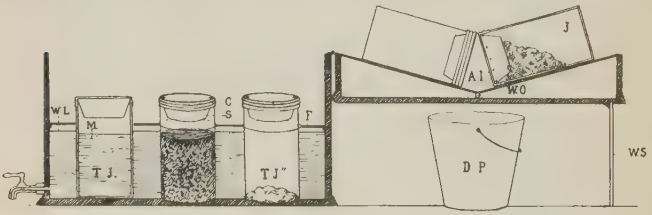

FIG. 46. Cross-section of the Wisconsin curd test, TJ-TJ", testing jars showing different stages of test; WL, water line; M, milk; F, frame; WS, stand to support cover; AI, drain holes; WO, water outlet; DP, drain pail.

minutes until it is firm. It is then cut fine with a case knife, and stirred at intervals for one-half to three-quarters of an hour sufficiently to keep the curd from matting under the whey. When the cubes are quite firm the whey is poured off and the curd left to mat at the bottom of the bottles if the old form of apparatus is used. The best tests are made when the separation of the whey is most complete. By allowing the samples to stand for a short time, more whey can be poured off, and the curd thereby rendered firmer. The water around the jars is kept at a temperature of 98°, the vat is cov-

ered, and the curds allowed to ferment in the sample jars for six to twelve hours.

During this time the impurities in any particular sample will cause gases to be developed in the curds so that by examining these, by smelling of them and cutting them with a sharp knife, those having a bad flavor, or a spongy or in any way abnormal texture may be easily detected, and thus traced to the milk causing the trouble.

Since the curd test was first described, several modifications have been made in the apparatus. In one of these the bottles are held in a covered metal frame so that all of them can be drained at once by inverting the frame.

155. By proceeding in the way described with the milk from the different cows in a herd, the mixed milk of which produced abnormal curds, the source of contamination in the herd may be located. Very often the trouble will be found to come from the cows drinking foul stagnant water or from fermenting matter in the stable. In the former case the pond or marsh must be fenced off, or the cows kept away from it in other ways; in the latter, a thorough cleaning and disinfection of the premises are required. If the milk of a single cow is the source of contamination, it must be kept by itself, until it is again normal; under such conditions the milk from the healthy cows may, of course, safely be sent to the factory.

156. The fermentation test. The Gerber fermentation test (see fig. 47) also furnishes a convenient method for examining the purity of different lots of milk. The test consists of a tin tank which can be heated by means of a small lamp,

and into which a rack fits, holding a certain number of cylindrical glass tubes; these are all numbered and provided with a mark and a tin cover. In making the test, the tubes are filled to the mark with milk, the number of each tube being recorded in a note book, opposite the name of the patron whose milk was placed therein. The tubes in the rack are put in the tank, which is two-thirds full of water; the temperature of the water is kept at 104-106° F., for six hours, when the rack is taken out, the tubes gently shaken, and the appearance of the milk, its odor, taste, etc., carefully noted in each case.

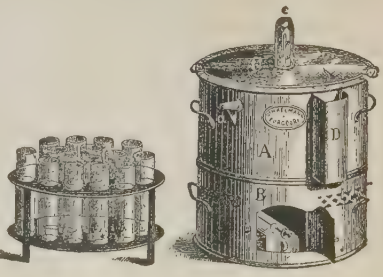

FIG. 47. The Gerber fermentation test.

The tubes are then again heated in the tank at the same temperature as before, for another six hours, when observations of the appearence of the milk in each tube are once more taken. The tainted milk may then easily be discovered by the abnormal coagulation of the sample. According to Gerber,[1] good and properly handled milk should not coagulate in less than twelve hours, when kept under the conditions described, and should not show anything abnormal when coagulated. Milk from sick cows and from cows in heat, or with diseased udders, will always coagulate in less than twelve hours. If the milk does not curdle within a day or two, it should be tested for preservatives (299).

157. The Monrad rennet test is used by cheese makers for determining the ripeness of milk. Fig. 48 shows the apparatus used in the test. 5 cc. of rennet extract is measured into a 50 cc. flask by means of a pipette; the pipette is rinsed with water, and the flask filled to the mark with water. 160 cc. of milk is now measured into the tin basin from the cylinder and slowly heated to exactly 86° F. 5 cc. of the dilute rennet solution is

[1] Die praktische Milchprüfung, p. 85.

then quickly added to the warm milk and the time required for coagulation noted.[1] Milk sufficiently ripe for cheddar cheese making will coagulate in 30 to 60 seconds, according to the strength of the rennet extract used.

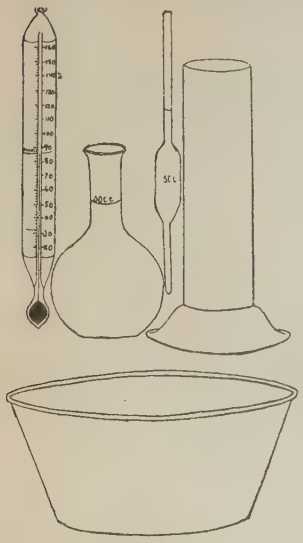

FIG. 48. **The Monrad** rennet test

158. **The Marschall rennet test** is used for the same purpose as the Monrad test. The directions for this test are as follows: Fill the small glass with pure water to the mark, pour into it one cc. of rennet extract and rinse the pipette in the same water. Fill the cup with milk to the zero mark, add the rennet, mix thoroughly and allow it to stand. The sweeter the milk is, the longer it will take to coagulate, and the more milk will run out of the cup before the point of coagulation is reached, when the flow of milk will cease. The time required for coagulating the milk is shown directly by a scale on the inside wall of the cup (see fig. 49).

FIG. 49. The Marschall rennet test.

1 Decker, Cheese Making, Revised ed., 1909, p. 39.

CHAPTER IX.

TESTING MILK ON THE FARM.

159. Variations in milk of single cows. The variations in the tests of milk of single cows from milking to milking or from day to day, are greater than many cow-owners suspect. There seems to be no uniformity in this variation, except that the quality of the milk produced generally improves with the progress of the period of lactation: even this may not be noticeable, however, except when the averages of a number of tests made at different stages during the lactation period are compared with each other. When a cow gives her maximum quantity of milk, shortly after calving, the quality of her milk is generally poorer (by one per cent. of fat or less) than when she is drying off. Strippers' milk is therefore, as a rule, richer in fat than the milk of fresh cows.

160. By testing separately every milking of a number of cows through their whole period of lactation, the results obtained have seemed to warrant the following conclusions in regard to the variations in the test of the milk from single cows, and it is believed that these conclusions allow of generalization.[1]

1. Some cows yield milk that tests about the same at every milking, and generally give a uniform quantity of milk from day to day.

[1] Illinois experiment station, bulletin 24.

2. Other cows give milk that varies in an unexplainable way from one milking to another. Neither the morning nor the evening milking is always the richer, and even if the interval between the two milkings is exactly the same, the quality as well as the quantity of milk produced will vary considerably. Such cows are generally of a nervous, excitable temperament, and are easily affected by changes in feed, drink, or surrounding conditions.

3. The milk of a sick cow, or of a cow in heat, as a rule, tests higher than when the cow is in normal condition; the milk yield generally decreases under such conditions; marked exceptions to this rule have, however, been observed.

4. Half-starved or underfed cows may give a small yield of milk testing higher than when the cows are properly nourished, probably on account of an accompanying feverish condition of the animal. The milk is, however, more generally of an abnormally low fat content, which may be readily increased to the normal per cent. of fat by liberal feeding.

5. Fat is the most variable constituent of milk, while the solids not fat vary within comparatively narrow limits. The summary of the analyses of more than 2400 samples of American milk calculated by Cooke[1] shows that while the fat content varies from 3.07 to 6.00 per cent., that of casein and albumen varies only from 2.92 to 4.30 per cent., or less than one and one-half per cent.

[1] Vermont experiment station, report for 1890, p. 97; Woll's Handbook for Farmers and Dairymen, Fifth ed., p. 250.

and the milk sugar and ash content increases but little (about .69 per cent.) within the range given.

6. A test of only one milking may give a very erroneous impression of the average quality of a certain cow's milk. A composite sample (see 179) taken from four or more successive milkings will represent the average quality of the milk which a cow produces at the time of sampling.

161. The variations that may occur in testing the milk of single cows, are illustrated by the following figures obtained in an experiment made at the Illinois experiment station,[1] in which the milk of each of six cows was weighed and analyzed daily during the whole period of lactation. Among the cows were pure-bred Jerseys, Shorthorns and Holsteins, the cows being from three to eight years of age and varying in weight from 850 to 1350 lbs. During a period of two months of the year[2] the cows were fed a heavy grain ration consisting of twelve lbs. of corn and cob meal, six lbs. of wheat bran, and six lbs. of linseed meal, per day per head. This system of feeding was tried for the purpose of increasing, if possible, the richness of the milk. The influence of this heavy grain feed, as well as that of the first pasture grass feed, on the quality and the quantity of the milk produced is shown in the following table, which gives the complete average data for one of the cows (No. 3). The records of the other cows are given in the publication referred to; they were similar to the one here given in so far as variations in quality are concerned.

[1] Bulletin 24.
[2] See 175.

Average results obtained in weighing and testing a cow's milk daily during one period of lactation.

MONTH	Live weight lbs.	Daily milk yield			Test of one day's milk			Yield of fat per day		
		Average lbs.	Highest lbs.	Lowest lbs.	Average per ct.	Highest per ct.	Lowest per ct.	Average lb.	Highest lb.	Lowest lb.
December	920	12.1	16.0	10.0	3.8	4.9	3.0	.46	.60	.34
January	927	16.0	17.7	14.0	3.7	4.6	2.7	.59	.76	.44
February	1035	16.1	17.7	13.5	3.6	5.8	3.2	.58	.84	.51
March	1047	14.3	16.0	12.5	3.8	4.7	3.4	.54	.61	.50
April	1054	13.8	16.5	11.5	4.0	5.8	3.0	.55	.72	.46
May	1079	14.5	17.2	10.0	3.8	4.6	3.4	.55	.70	.44
June	1105	12.1	14.0	9.2	3.9	4.6	3.2	.47	.57	.35
July	1180	9.3	12.2	6.0	4.2	6.2	2.8	.39	.60	.27
August	1130	6.4	9.3	3.5	4.7	7.9	2.9	.30	.50	.16

162. The average test of this cow's milk for her whole period of lactation was 3.8 per cent. of fat (i. e., the total quantity of fat produced ÷ total milk yield × 100); twice during this time the milk of the cow tested as high as 5.8 per cent., and once as low as 2.7 per cent. The average weight of milk produced per day by the cow was 14 lbs.; this multiplied by her average test, 3.8, shows that she produced on the average .53 lb., or about one-half of a pound, of butter fat per day during her lactation period. If, however, her butter-producing capacity had been judged by the test of her milk for one day only, this test might have been made either on the day when her milk tested 5.8 per cent., or when it was as low as 2.7 per cent. Both of these tests were made in mid-winter when the cow gave about 16 lbs. of milk a day. Multiplying this quantity by .058 gives .93 lb. of fat, and by .027 gives .43 lb. of fat. Either

result would show the butter fat produced by the cow on certain days, but neither gives a correct record of her actual average daily performance for this lactation period.

A sufficient number and variety of tests of the milk of many cows have been made to prove that there is no definite regularity in the daily variations in the richness of the milk of single cows. The only change in the quality of milk common to all cows is, as stated, the natural increase in fat content as the cows are drying off, and even in this case the improvement in the quality of the milk sometimes does not occur until the milk yield has decreased very materially.

163. Causes of variations in fat content. The quality of a cow's milk is, as a rule, decidedly influenced by the following conditions:

Length of interval between milkings.
Change of feed.
Change of milkers.
Rapidity of milking.
Exposure to rain or bad weather.
Rough treatment.
Unusual excitement or sickness.

164. Disturbances like those enumerated frequently increase the richness of the milk for one, and sometimes for several milkings, but a decrease in quality follows during the gradual return to normal conditions, and taken as a whole there is a considerable falling off in the total production of milk and butter fat by the cow, on account of the nervous excitement which she has gone through. Aside from changes due to well-

definable causes like those given above, the quality of some cows' milk will often change considerably without any apparent cause. The dairyman who is in the habit of making tests of the milk of his individual cows at regular intervals will have abundant material for study in the results obtained, and he will soon be able to tell from the tests made, if these are continued for several days, whether or not the cows are in a normal healthy condition or have been subjected to excitement or abuse in any way.

165. Number of tests required during a period of lactation in testing cows. The daily records of the six cows referred to on page 142 furnish data for comparing their total production of milk and butter fat during one period of lactation, as found from the daily weights and tests of their milk, with the total amount calculated from weights and tests made at intervals of 7, 10, 15 or 30 days. The averages of all results obtained with each of the six cows show that weighing and testing the milk of a cow every seventh day gave 98 per cent. of the total milk and butter fat, which according to her daily record was the total product. Tests made one day every two weeks gave 97.6 per cent. of the total milk, and 98.5 per cent. of the total butter fat, and tests made one day per month, or only ten times during the period of lactation, gave 96.4 per cent. of the total milk, and 97 per cent. of the total production of butter fat.

166. The record of one of the cows will show how these calculations are made: It was found from the daily weights and tests that cow No. 1, in one lactation period of 307 days, gave 5,044 lbs. of milk which con-

tained 254 lbs. of butter fat. Selecting every thirtieth day of her record as testing day, the total production of milk and fat is shown to be as follows:

Production of milk and butter fat per day.

Testing day	Weight of Milk	Test of milk	Yield of butter fat
Nov. 4	20.5	4.7	.96
Dec. 4	18.7	4.6	.86
Jan. 3	17.7	4.9	.86
Feb. 2	20.0	4.5	.90
Mar. 3	18.2	4.7	.86
April 2	19.5	4.4	.81
May 2	17.7	4.8	.85
June 1	13.1	5.5	.72
July 1	12.2	6.2	.76
July 31	3.2	7.2	.23
Total	160.8 lbs.	----	7.81 lbs.
Average per day	16.08 lbs.	4.85	.78 lb.

The average daily production of the cow, according to the figures given in the preceding table, was about 16 lbs. of milk, containing .78 lb. of butter fat. Multiplying these figures by 307, the number of days during which the cow was milked, gives 4,912 lbs. of milk and 240 lbs. of fat. This is 132 lbs. of milk and 14 lbs. of fat less than the total weights of milk and butter fat, as found by the daily weights and tests, or 2.8 and 5.5 per cent. less, for milk- and fat production, respectively. This is, however, calculated from only ten single weights and tests, while it required over 600 weighings and 300 tests of the milk to obtain the exact amount.

Similar calculations from the records of the other cows gave fully as close results, showing that quite sat-

isfactory data as to the total production of milk and butter fat of a cow may be obtained by making correct weighings and tests of her full day's milk once every thirty days.

166a. Official tests of dairy cows. The various experiment stations conduct tests of dairy cows for breeders and farmers, by which means records of production of milk and butter fat are obtained for periods of 7 or 30 days, or for an entire year. This system of official testing is described in bulletins issued by several stations.[1]

167. When to test a cow. The Vermont experiment station for several years made a special study of the question when a cow should be tested in order to give a correct idea of the whole year's production, when only one or two tests are to be made during the lactation period.[2] The results obtained may be briefly summarized as follows:

a. *As to quality of milk produced.* If two tests of each cow's milk are to be made during the same lactation period, it is recommended to take composite samples at the intervals given below.

	FIRST SAMPLE	SECOND SAMPLE
For spring cows,	6 weeks after calving	6½-7½ mos. after calving
For summer "	8 " " "	6 -7 " " "
For fall "	8-10 " " "	5½-7 " " "

If only one test is to be made, approximately correct results may be obtained by testing the milk during the

[1] See, e. g., Wis. exp. station bull. 191 and 242; also bull. 226, The Wisconsin Dairy Cow Competition, and research bull. 26, Studies in Dairy Production, published by this station.

[2] Sixth report, 1882, p. 106; Ninth report, 1895, p. 176.

sixth month from calving, in case of spring cows; during the third to fifth month in case of summer-calving cows, and during the fifth to seventh month for fall-calving cows.

In all cases composite samples of the milk for at least two days should be taken (169). "The test of a single sample, drawn from a single milking or day, will not of necessity, or indeed usually, give trustworthy results."

b. *As to quantity of milk produced.* The milk may be weighed for two days in the middle of the month, and the entire month's yield obtained with considerable accuracy (barring sickness and drying off), by multiplying the sum by a factor, according to the number of days in the different months. The weighing is readily done by means of a spring balance, the hand of which is set back so that the empty pail brings it to zero (fig. 50). If several pails are to be used, they should first be made to weigh the same by putting a little solder on the lighter pails. Milk scales which weigh and automatically register the yield of milk from twenty cows have been placed on the market, but so far as known have not proved satisfactory.

FIG. 50. Milk scale.

168. Sampling milk of single cows. In sampling the milk of single cows, all the milk obtained at the milking must be carefully mixed, by pouring it from one vessel to another a few times, or stirring it thoroughly by means of a dipper moved up and down, as well as horizontally, in the pail or can in which it is

held; a sample for testing purposes is then taken at once. A correct sample of a cow's milk cannot be obtained by milking directly into a small bottle from one teat, or by filling the bottle with a little milk from each teat, or by taking some of the first, middle and last milk drawn from the udder. Such samples cannot possibly represent the average quality of the milk of one entire milking, since there is as much difference between the first and the last portions of a milking, as between milk and cream.[1] Lack of care in taking a fair sample is the cause of many surprising results obtained in testing the milk of single cows.

169. Composite samples. When a cow is to be tested for milk production she should be milked dry the last milking previous to the day when the test is to be made. The entire quantity of milk obtained at each milking is mixed and sampled separately. On account of the variations in the composition of the milk, a number of tests of successive milkings must be made. As this involves considerable labor, the plan of taking composite samples is preferable; the method of composite sampling and testing is explained in detail under the second subdivision of Chapter X (180); suffice it here to say that the method followed in the case of single cows' or herd milk is to take about an ounce of the thoroughly mixed milk of each milking; this is placed in a pint or quart glass jar containing a small quantity of some preservative, preferably about half a gram (8 grains) of powdered potassium bi-chromate. If a number of composite samples of the milk of single cows are taken, each jar should

[1] Agricultural Science, 6, pp. 540–42.

be labeled with the number or name of the particular cow. Composite tests are generally taken for two or four days or for a week. If continued for a week, the jars will contain at the end of this time a mixture of the milk of fourteen milkings. The composite sample is then carefully mixed by pouring it gently a few times from one jar to another, and is tested in the ordinary manner. The result of this test shows the average quality of the milk produced by the cow during the time the milk was sampled.

As the amounts as well as the quality of the milk produced by single cows vary somewhat from day to day and from milking to milking, it is desirable in testing single cows, especially when the test includes only a few days, to take a proportionate part (an *aliquot*) of each milking for the composite test sample. This is easily done by means of a Scovell sampling tube, the use of which is explained in another place (183), or by a 25 cc. pipette divided into $\frac{1}{10}$ cc.; in using the latter apparatus as many cubic centimeters and tenths of a cubic centimeter of milk are conveniently taken each time for the composite sample as the weight of milk in pounds and tenths of a pound produced by the cow.[1]

170. Testing warm milk. The opinion is sometimes expressed that a considerable error is introduced by measuring out milk warm from the cow for the Babcock test, since milk expands on being warmed, and a too small quantity is obtained in this manner. By calculation of the expansion of milk between different temperatures it is found that

[1] Decker, Wis. experiment station, report 16, p. 155.

1 cc. of milk at 17.5° C. (room temperature) will have a volume of 1.006289 cc. at 37° C. (blood-heat), i. e., an error of less than .03 per cent. is introduced by measuring out milk of ordinary quality at the latter temperature. While the temperature has therefore practically no importance, the air incorporated in the milk during the milking process will introduce an appreciable error in the testing, and samples of milk should therefore be left for an hour or more after milking before the milk is measured into the test bottles. By this time the specific gravity of the samples can also be correctly determined (113).

171. Size of the testing sample. Four ounces are a sufficient quantity for a sample of milk if it is desired to determine its per cent. of fat only; if the milk is to be tested with a lactometer, when adulteration is suspected, about a pint sample is needed. If this sample of milk is put into a bottle and carried or sent away from the farm to be tested, the bottle should be filled with milk clear up to the neck to prevent a partial churning of butter in the sample during transportation (30).

172. Variations in herd milk. While considerable variations in the quality of the milk of single cows are often met with, a mixture of the milk of several cows, or of a whole herd, is comparatively uniform from day to day; the individual differences tend to balance each other so that variations, when they do occur, are less marked than in case of milk of single cows. There are, however, at times marked variations also in the test of herd milk on successive days; the following figures from the dairy tests conducted at the World's Columbian Ex-

position in Chicago in 1893 illustrate the correctness of this statement. The tests included twenty-five Jersey and Guernsey cows each and twenty-four Shorthorn cows.

Tests of herd milk on successive days.

Date	Jersey	Guernsey	Shorthorn
July 16, 1893	4.8 per cent.	4.6 per cent.	3.8 per cent.
July 17, 1893	5.0 "	4.5 "	3.8 "
July 18, 1893	4.7 "	4.4 "	3.8 "
July 19, 1893	4.6 "	4.6 "	3.7 "
July 20, 1893	5.0 "	4.5 "	3.8 "

On July 17, 1893, the mixed milk of the Jersey cows tested two-tenths of one per cent. higher than on the preceding day; the Guernsey herd milk tested one-tenth of one per cent. lower, while the Shorthorn milk did not change in composition; comparing the tests on July 19 and 20, we find that the Jersey and Shorthorn milk tested four-tenths and one-tenth of one per cent. higher, respectively, on the latter day than on the former, and the Guernsey milk tested one-tenth of one per cent. lower. There was no change in the feed of the cows or in the method of handling them on these days.

173. Ranges in variations of herd milk. According to Fleischmann,[1] the composition of herd milk will vary on single days from the average values for the year, expressed in per cent. of the latter, as follows:

The specific gravity (expressed in degrees) may go above or below the yearly average by more than 10 per cent.

The per cent. of fat may go above or below the yearly average by more than 30 per cent.

[1] Book of the Dairy, p. 32.

The per cent. of total solids may go above or below the yearly average by more than 14 per cent.

The per cent. of solids not fat may go above or below the yearly average by more than 10 per cent.

To illustrate, if the average test of a herd during a whole period of lactation is 4.0 per cent., the test on a single day may exceed $4.0+\frac{30}{100}\times4.0=5.2$, or may go below 2.8 per cent. (viz., $4.0-\frac{30}{100}\times4.0$); if the average specific gravity is 1.031 (lactometer degrees, 31)[1] the specific gravity of the milk on a single day may vary between 1.0279 and 1.0341 ($31+\frac{10}{100}\times31=34.1$; $31-\frac{10}{100}\times31=27.9$).

174. Influence of heavy grain-feeding on the quality of milk. If cows are not half-starved or underfed, an increase in the feeding ration will not materially change the richness of the milk produced; this has been shown by numerous careful feeding experiments conducted under a great variety of conditions and in many countries. Good dairy cows will almost invariably give more milk when their rations are increased, so long as they are not overfed, but the milk will remain of about the same quality after the first few days are passed as before this time, provided the cows are in good health and under normal conditions. Any change in the feed of cows will usually bring about an *immediate* change in the fat content of the milk, as a rule increasing it to some extent, but in the course of a few days, when the cows have become accustomed to their new feed, the fat content will again return to its normal amount.

175. The records of the cows included in the feeding experiment at the Illinois station, to which reference has been made on p. 144, furnish illustrations as to the effect of heavy feeding on the quality of milk. The

[1] See page 103.

feed, as well as the milk of the cows, was weighed each day of the experiment. During the month of December each cow was fed a daily ration consisting of 10 lbs. of timothy hay, 20 lbs. of corn silage and 2 lbs. of oil meal; the table on p. 145 shows that cow No. 3 produced on this feed an average of 12.1 lbs. of milk, testing 3.8 per cent. of fat. In January the grain feed was gradually increased until the ration consisted of 12 lbs. of timothy hay, 8 lbs. of corn and cob meal, 4 lbs. of wheat bran, and 4 lbs. of oil meal. All the cows gained in milk on this feed; cow No. 3 thus gave an average of 4 lbs. more milk per day in January than in December, but the average test of her milk was 3.7 per cent., or one-tenth of one per cent. lower than during the preceding month. The heavy grain-feeding was continued through February and March, when it reached 12 lbs. of timothy hay, 12 lbs. of corn and cob meal, 6 lbs. of wheat bran and 6 lbs. of oil meal per day. The records show that the flow of milk kept up to 16 lbs. per day in February in case of this cow, but fell to 14 lbs. in March and April, the average test of the milk being, in February 3.6, in March 3.8, and in April 4.0 per cent. The milk was, therefore, somewhat richer in April than in December, but not more so than is found normally, owing to the progress of the period of lactation.

176. Influence of pasture on the quality of milk. On May 1, the cows were given luxuriant pasture feed and no grain; a slight increase in the average amount of milk produced per day followed, with a reduction in the test, this being 3.8 per cent., the same as in December.

During all these changes of feed there was, therefore, not much change in the richness of the milk, while the flow of milk was increased by the heavy grain feeding for several months, as well as by the change from grain-feeding in the barn to pasture feed with no grain.[1] As a general rule, the test of the milk will be increased by a few tenths of a per cent. during the first couple of weeks after the cows have been turned out to pasture in the spring. The increase is perhaps due as much to the stimulating influence of out-door life after the confinement in the stable during the winter and spring, as to the change in the feed of the cows. After a brief period the milk will again change back to its normal fat content.

177. The increase which has often been observed in the amount of butter produced by a cow, as a result of a change in feed, doubtless as a rule comes from the fact that more, but not richer milk is produced. The quality of milk which a cow produces is as natural to her as is the color of her hair and is not materially changed by any special system of normal feeding.[2]

[1] For further data on this point, see Cornell (N. Y.) exp. sta. bulletins 13, 22, 36 and 49; N. D. exp. sta., bull. 16; Kansas exp. sta., report, 1888; Hoard's Dairyman, 1896, pp. 924–5; W. Va. exp. sta., b. 109.

[2] On this point numerous discussions have taken place in the past in the agricultural press of this and foreign countries, and the subject has been under debate at nearly every gathering of farmers where feeding problems have been considered. Many farmers are firm in their belief that butter fat can be "fed into" the milk of a cow, and would take exception to the conclusion drawn in the preceding. The results of careful investigations by our best dairy authorities point conclusively, however, in the direction stated, and the evidence on this point is overwhelmingly against the opinion that the fat content of the milk can be materially and for any length of time increased by changes in the system of feeding. The most conclusive evidence in this line is perhaps

178. Method of improving the quality of milk. The quality of the milk produced by a herd can generally be improved by selection and breeding, i. e., by disposing of the cows giving poor milk, say below 3 per cent. of fat, and by breeding to a pure-bred bull of a strain that is known to produce rich milk. This method cannot work wonders in a day, or even in a year, but it is the only certain way we have of improving the quality of the milk produced by our cows.

It may be well in this connection to call attention to the fact that the quality of the milk which a cow produces is only one phase of the question; the quantity is another, and an equally important one. Much less dissatisfaction and complaint about low tests among patrons of creameries and cheese factories would arise if this fact was more generally kept in mind. A cow giving 3 per cent. milk should not be condemned because her milk does not test 5 per cent.; she may give twice as much milk per day as a 5 per cent cow, and will therefore produce considerably more butter fat. The point whether or not a cow is a persistent milker is also of primary importance; a production of 300 lbs. of butter fat during a whole period of lactation is a rather high dairy standard, but one reached by many herds,

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the Danish co-operative cow-feeding experiments, conducted during the nineties with over 2,000 cows in all. The conclusion arrived at by the Copenhagen experiment station, under whose direction the experiments have been conducted, is: that the changes of feed made in the different lots of cows included on the experiments had practically no influence on the chemical composition (the fat content) of the milk produced. In these experiments grain feeds were fed against roots, oil cake, wheat bran or shorts; grain and oil cake were furthermore fed against roots, and roots were given as an additional feed to the standard rations tried,—in all cases with practically negative results so far as changes in the fat contents of the milk produced are concerned.

as the average for all mature cows in the herd. It should be remembered that a high production of butter fat in the course of the whole period of lactation is of more importance than a very high test.

Questions.

1. How does the test of the milk yielded by a cow generally change with the advance of the period of lactation?
2. Mention at least six causes of variations in the test of a cow's milk.
3. How is an accurate sample taken of a cow's milk?
4. Between which limits is the test of milk of single cows and of a herd likely to vary?
5. Will it introduce any error in the test of a cow's milk to measure out the sample directly after milking? If so, how much?
6. How many times should the milk of a cow be weighed and tested to calculate the total production of milk and butter fat by the cow during a whole period of lactation?
7. What is an official test of a cow?
8. How does the test, as a general rule, change during the first couple of weeks after the cows are let out on pasture in the the spring?
9. How do changes in the feed of a cow influence the quantity and the quality of her milk?

CHAPTER X.

COMPOSITE SAMPLES OF MILK.

179. Shortly after milk testing had been introduced to some extent in creameries and cheese factories, it was suggested by Patrick, then of the Iowa experiment station,[1] that a great saving in labor, without affecting the accuracy of the results, could be obtained by testing a mixture of the daily samples of milk from one source, instead of each one of these samples. Such a mixture is called a *composite sample.* The usual methods of taking such samples at creameries and cheese factories are as follows:

FIG. 51. Taking test samples at in-take.

180. Methods of taking composite samples. a. Use of tin dipper. Either pint or quart fruit jars, or milk bottles provided with a cover, are used for receiving the daily samples. One of these jars is supplied for each

[1] Bulletin 9, May 1890.

patron of the factory and is labeled with his name or number. A small quantity of preservative (bi-chromate of potash, corrosive sublimate, etc., see 190) is added to each jar; these are placed on shelves or somewhere within easy reach of the operator who inspects and weighs the milk as it is received at the factory. When all the milk delivered by a patron is poured into the weighing can and weighed, a small portion thereof, usually about an ounce, is put into the jar labeled with the name or number of the patron. The samples are conveniently taken by means of a small tin dipper holding about an ounce. This sampling is continued for a week, ten days, or sometimes two weeks, a portion of each patron's milk being added to his particular jar every time he delivers milk. A test of these composite samples takes the place of separate daily tests and gives information regarding the average quality of the milk delivered by each patron during the period of sampling. The weight of butter fat which each patron brought to the factory in his milk during this time, is obtained by multiplying the total weight of milk delivered during the sampling period by the test of the composite sample, dividing the product by 100.

181. This method of taking composite samples has been proved to be practically correct. It is absolutely correct only when the same weight of milk is delivered daily by the patron. If this is not the case, the size of the various small samples should bear a definite relation to the milk delivered; one sixteen-hundredth, or one two-thousandth of the amount of milk furnished should, for instance, be taken for the composite sample from

each lot of milk. This can easily be done by means of special sampling devices (see 182 *et seq.*). As the quantities of the milk delivered from day to day by each patron vary but little, perhaps not exceeding 10 per cent. of the milk delivered, the error introduced by taking a uniform sample, e. g., an ounce of milk, each time is, however, small and it may not be necessary to take cognizance of it in factory work. This method of composite sampling described is quite generally adopted in separator creameries and cheese factories, where the payment for the milk is based on its quality.

In order to obtain reliable results by composite sampling it is essential that each lot of milk sampled shall be sweet and in good condition, containing no lumps of curdled milk or butter granules. The milk should of course always be evenly mixed before the sample is taken.

182. b. **Drip sample.** Composite samples are sometimes taken at creameries and cheese factories by collecting in a small dish the milk that drips through a fine hole in the bottom of the conductor spout through which the milk runs from the weighing can to the receiving vat or tank. A small portion of the drip collected each day is placed in the composite sample jar, or the quantity of drip is regulated so that all of it may be taken. In the latter case the quantity of milk delivered will enter into the composite sampling as well as its quality and the sample from, say 200 lbs. of milk, will be twice as large as the sample from 100 lbs. of milk.

Where it is desired to vary the size of samples according to the quantity of milk delivered from day to day,

it is necessary to adopt the method of collecting drip samples just explained, or to make use of special sampling devices, like the "milk thief," the Scovell, Equity, McKay, and Michels sampling tubes.[1] The principle of these tubes is the same, and it will be sufficient to describe here only a few of them.

Fig. 52 Scovell milk sampling tube.

183. e. The Scovell sampling tube. This convenient device for sampling milk[2] (fig. 52) consists of a drawn copper or brass tube, one-half to one inch in diameter; it is open at both ends, the lower end sliding snugly in a cap provided with three elliptical openings at the side, through which the milk is admitted. The milk to be sampled is poured into a cylindrical pail, or the factory weighing can, and the tube, with the cap set so that the apertures are left open, is lowered into the milk until it touches the bottom of the can. The tube will be filled instantly to the level of the milk in the can and is then pushed down against the bottom of the can, thereby closing the apertures of the cap and confining within the tube a column of milk representing exactly the quality of the milk in the can and forming an aliquot part thereof. The milk in the sampling tube is then emptied into the composite sample jar by turning the tube upside down

[1] A recent Wisconsin law (Chap. 99, laws of 1907) provides that in sampling cream or milk from which composite tests are to be made to determine the per cent of butter fat therein, no such sampling shall be lawful, unless a sample be taken from each weighing, and the quantity thus used shall be proportioned to the total weight of cream or milk tested.

[2] Kentucky experiment station. 8th report, pp. xxvi-xxvii.

184. If the diameter of the sampling pail used is 8 inches, and that of the sampling tube ½ inch, the quantity of milk secured in the tube will always stand in the ratio to that of the milk in the pail, of $(\frac{1}{2})^2$ to 8^2,[1] that is, as 1 to 256, no matter how much or how little milk there is in the pail, the sample will represent $\frac{1}{256}$ part of the milk. For composite sampling of the milk of single cows, this proportion will prove about right; if more milk is wanted for a sub-sample, dip twice, or pour the milk to be sampled into a can of smaller diameter. If the mixed milk from a number of cows is to be sampled, a wider sampling can may be used. By adjusting the diameter of the tube or the can, any desired proportion of milk can be obtained in the sample.

For factory sampling, with a weighing can 26 inches in diameter, a tube three-quarters of an inch in diameter will be found of proper dimensions.

In using these tubes, the milk or cream must in all cases be in *cylindrical* cans when the sample is drawn.

The sampling tube will furnish a correct sample of the milk in the can, even if this has been left standing for some time; it is better, however, to take out the sample soon after the milk has been poured into the can, as the possible error of cream adhering to the sides of the sampling tube is then avoided.

185. The accuracy of the sampling of milk by means of the Scovell tube was proved beyond dispute in the breed tests conducted at the World's Columbian Expo-

[1] The contents of a cylinder are represented by the formula $\pi r^2 h$, r being the radius of the cylinder, and h its height. The relation between two cylinders of the same height, the radii of which are R and r, is therefore as $\pi R^2 h$ to $\pi r^2 h$, or as R^2 to r^2.

sition in 1893, in which tests this method was adopted for sampling the milk produced by the single cows and the different herds.[1] The data obtained in these breed tests also furnish abundant proof of the accuracy of the Babcock test.

186. Accuracy of the described methods of sampling. An experiment made at the Wisconsin Dairy School may here be cited, showing that concordant results will be obtained by the use of the drip sampling method and the Scovell tube. Two composite samples were taken from fifty different lots of milk, amounting to about 6,000 lbs. in the aggregate. One sample was taken of the drip from a hole in the conductor spout through which the milk passed from the weighing can; the other was taken from the weighing can by means of a Scovell sampling tube. The following percentages of fat were found in each of these samples:[2]

	Babcock test	Gravimetric analysis
Drip composite sample	4.0 per cent.	4.04 per cent.
Scovell tube composite sample	4.0 per cent.	4.06 per cent.

187. d. **The McKay sampler** (fig. 53), constructed by Professor G. L. McKay, formerly of Iowa experiment station, consists of two nickel-plated brass tubes that telescope one within the other; both have a milled slot so made that when the handles stand together the slot is open; by turning the handles at right angles the

[1] Kentucky experiment station, 8th report, pp. xxx-xxxi. Another form of a milk sampling tube in use at the Iowa experiment station was described and illustrated by Mr. Eckles in Breeder's Gazette, May 19, 1897.

[2] See also 199 *et seq.*

FIG. 53. The McKay sampler.

slot is closed. The sampler is made in two lengths, 21 and 18 inches, and has been found very convenient for sampling either milk or cream.

187a. e. Michels' cream-sampling tube consists of a modified Scovell sampler in a tin jacket. It was constructed by Professor John Michels, late of North Carolina agricultural college. This sampler renders possible an accurate and rapid sampling of any cream, regardless of its richness and acidity, without stirring the cream.

188. f. Composite sampling with a "one-third sample pipette." Milk is sometimes sampled directly from the weighing can into the Babcock test bottle by means of a pipette holding 5.87 cc., which is one-third the size of the regular pipette. This quantity is measured into the test bottle from three successive lots of milk from the same patron and the test then made in the ordinary manner. In this way one test shows the average composition of the milk delivered during three successive days or deliveries. When this method is adopted, as many test bottles are provided as there are patrons; there is no

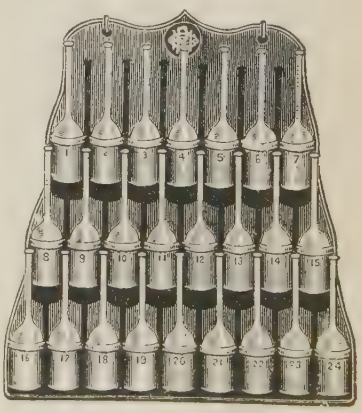

FIG. 55. Test-bottle rack for use in creameries and cheese factories.

need of using any preservatives for milk in this case. Fig. 55 shows a convenient rack for holding the test bottles used in composite sampling with a "one-third sample pipette."

Accurate results can be obtained by this method of sampling, if care is taken in measuring out the milk, and if it is not frozen or contains lumps of cream. It is doubtful if the method has any advantage over the usual method of composite sampling. If milk is delivered daily and each lot is sampled with the one-third pipette, twice or three times the number of tests are required as when composite samples are taken in jars and tested once every week or ten days. This method furthermore takes a little more time in the daily sampling than the other, as the quantity of milk must be measured out accurately each time. If a test bottle is accidently broken or some milk spilled, the opportunity of ascertaining the fat content of the milk delivered during the three days is lost; if a similar accident should occur in testing composite samples collected in jars, another test can readily be made.

Preservatives for Composite Samples.

189. When milk is kept for any length of time under ordinary conditions, it will soon turn sour and become loppered, and further decomposition shortly sets in, which renders the sampling of the milk both difficult and unsatisfactory (19). The period during which milk will remain in an apparently sweet or fresh condition varies with the temperature at which it is kept, and with the cleanliness of the milk. It will not generally remain sweet longer than two days at the outside, at ordinary summer or room temperature.

In order to preserve composite samples of milk in a proper condition for testing, some chemical which will check or prevent the fermentation of the milk must be added to it. A number of substances have been proposed for this purpose.

190. Bi-chromate of potash. This preservative is preferred by many because it is relatively harmless, cheap and efficient. The bi-chromate method for preserving samples of milk was proposed by Mr. J. A. Alen, city chemist of Gothenburg, Sweden, in 1892,[1] and has been generally adopted in dairy regions in this country and abroad. While not perfectly harmless, the bi-chromate is not a violent poison like other chemicals proposed for this purpose, and no accidents are liable to result from its use.

191. The quantity of bi-chromate necessary for preserving half a pint to a pint of milk for a period of one or two weeks is about one-half gram (nearly 8 grains), about one-half as much as can be placed on a dime.

According to Winton and Ogden,[2] a .22-inch pistol cartridge shell ½ inch long, or a .32-inch caliber shell ¼ inch long, when loosely filled, will hold enough powdered bi-chromate to preserve ½ pint, and a .32-inch caliber shell ½ inch long will hold enough to preserve one pint. These shells may be conveniently handled by soldering to them a piece of stiff wire which serves as a handle. The amount of bi-chromate placed in each composite sample jar would fill about half the space representing one per cent. in the neck of a Babcock milk test bottle.

192. The first portions of milk added to the composite sample jars containing the specified amount of bi-chromate will be colored almost red, but as more

[1] Biedermann's Centralblatt, 1892, p. 549.
[2] Connecticut experiment station, report for 1884, p. 222

milk is added day by day, its color will become lighter yellow. The complete sample should have a light straw color; such samples are most easily mixed with acid when tested. If more bi-chromate is used, the solution of the casein in the acid is rendered difficult and requires persistent shaking. Bi-chromate can be bought at drug stores or from dairy supply dealers at about 30 cents a pound. Powdered bi-chromate of potash should be ordered, and not crystals, as the latter dissolve only slowly in the milk. Bi-chromate tablets containing the correct quantity of preservative for a quart or pint sample have also been placed on the market and will be found convenient.

193. Corrosive sublimate tablets for composite samples. During late years corrosive sublimate tablets have come into general use in factories. These contain mercuric chlorid with anilin color (rosanilin).[1] The coloring matter is added to give a rose color to the sample preserved, thus showing that the milk is not fit for consumption; the bi-chromate giving naturally a yellow color to the milk, renders unnecessary the addition of any special coloring matter.

Compounds containing corrosive sublimate are violent poisons and must always be handled with the greatest care, lest they get into the hands of children or persons not familiar with their poisonous properties; they will preserve the milk longer than bi-chromate when applied in sufficient quantities.

Among other substances recommended for use in butter or cheese factories as milk preservatives for com-

[1] Iowa experiment station, bulletins 9, 11, 32.

posite samples may be mentioned formaldehyde, boracic-acid compounds, chloroform, carbon bi-sulfid,[1] copper ammonium sulfate, sodium fluorid and ammonia glycerin (sp. gr., 1.031).

194. Care of composite samples. The composite sample jars should be kept covered to prevent loss by evaporation, and in a cool, dark place, or at least out of direct sunlight when bi-chromate of potash is used as a preservative; the chromic acid formed by the reducing influence of light on chromate solutions produces a leathery cream which it is difficult to dissolve in sulfuric acid.

A coating of white shellac has been suggested to protect the labels of the composite sample jars. The shellac is applied after the names of the patrons have been written on the labels, and when these have been put on the jars. Gummed labels, 1x2½ inches, answer this purpose well.

Numbers are sometimes ground on the sample jar or stamped on brass tags attached to the jars by a wire.

In keeping the milk from day to day, care should be taken that the cream forming on the milk does not stick to the sides of the jars in patches above the level of the milk. Unless the daily handling of the jars and the addition of fresh portions of milk be done carefully, the cream will become lumpy and will dry on the sides of the jars. In some cases it is nearly impossible to evenly distribute this dried cream through the entire sample at testing time so as to make the composite

[1] Delaware experiment station, eighth report, 1896, which also see for trials with a large number of different preservatives.

sample a true representative of the different lots of milk from which it has been taken.

195. Every time a new portion of milk is added to the jar this should be given a gentle horizontal rotary motion, thereby mixing the cream already formed in the jar with the milk and loosening the cream sticking to its side. This manipulation also prevents the surface of the milk from becoming covered with a layer of partially dried leathery cream.

Composite samples having patches of dried cream on the inside of the jar are the result of carelessness or ignorance on the part of the operator. If proper attention is given to the daily handling of the composite samples, the cream formed in the jars can again be evenly mixed with the milk without difficulty.

196. Fallacy of averaging percentages. A composite sample of milk should represent the average quality of the various lots of milk of which it is made up. This will be true if a definite aliquot portion or fraction of the different lots of milk is taken. If the weights of, say ten different lots of milk, are added together and the sum divided by ten, the quotient will represent the average *weight* per lot of milk, but an average of the tests of the different lots obtained in this way may not be the correct average *test* of the entire quantity of milk. The accuracy of such an average figure will depend on the uniformity in the composition and weights of the ten lots of milk. When there is no uniformity, the weights of the different lots of milk as well as their tests must be considered. The following example will illustrate the difference between the arithmetical aver-

age of a number of single tests and the true average test of the various lots.

Methods of calculating average percentages.

I. Milk varying in weights and tests				II. Milk of uniform weights and tests			
Lot	Weight of milk	Test of milk	Weight of fat	Lot	Weight of milk	Test of milk	Weight of fat
	lbs.	per ct.	lbs.		lbs.	per ct.	lbs.
I	120	.5	4.2	I	250	4.2	10.5
II	570	5.0	28.5	II	225	4.0	9.0
III	360	5.2	18.7	III	240	4.3	10.3
IV	55	3.0	1.6	IV	238	4.1	9.7
V	82	4.0	3.2	V	234	4.4	10.3
Total	1187		56.2	Total	1187		49.8
Average	237	4.14	11.24	Average	237	4.20	10.0
True average test		4.73*		True average test		4.22	

*$\frac{56.2 \times 100}{1187} = 4.73$ $\frac{49.8 \times 100}{1187} = 4.22$

197. The figures given in the table show that when the different lots of milk vary in test and weight, as in the first case, the correct average test of the 1187 lbs. of milk is not found by dividing the sum of these tests by five, which would give 4.14 per cent.; but by dividing 56.2 (the total amount of fat in the mixed milk) by 1187 (the total amount of milk), which is 4.73; this is the correct average test of the mixed milk made up of the five different lots.

In the second case, the variations in both the weights of the different lots of milk and their tests, are comparatively small, and both methods of calculation give therefore practically the same average test; but also in this case, the correct average test is found by dividing

the total amount of fat by the total quantity of milk, making 4.22 per cent., instead of 4.20 per cent., which is the arithmetical mean of the five tests. The quantities of milk in the various lots do not enter into the calculation of the latter.[1]

198. The second example represents more nearly than the first one the actual conditions met with at creameries and cheese factories. As a rule, the mixed milk from a herd of cows does not vary more in total weight or tests, within a short period of time like one to two weeks, than the figures given in this example. On account of this fact, samples taken, for instance, with a small dipper may give satisfactory results to all parties concerned. If the different lots of milk varied in weight and test from day to day, as shown in the first case, it would be necessary to use a "milk thief" or one of the sampling tubes for taking the composite samples; the size of each of the samples taken would then represent an exact aliquot portion of the various lots of milk (182).

199. A patron's dilemma. The following incident will further explain the difficulties met with in calculating average tests of different lots of milk.

The weekly composite sample of the milk supplied by a creamery patron from his herd of 21 cows tested 4.0 per cent. fat. One day the farmer brought to the creamery a sample of the morning's milk from each of his cows, and had them tested; after adding the tests together and dividing the sum by 21, he obtained an average figure of 5.1 per cent. of fat. From this he concluded that the average test of the milk from his cows

[1] In the experiment given on p. 148, the arithmetical mean of the tests is 5.15 per cent., while the true average fat content of milk is 4.85 per cent.

ought to be 5.1, instead of 4.0, and naturally asked for an explanation.

The first thing done was to show him that while 5.1 was the correct average of the figures representing the tests of his twenty-one cows, it was not a correct average test of the mixed milk from all his cows, as he had not considered, in calculating this average, the quantities of milk yielded by each cow; the following illustration was used:

Cow No. 1, yield	25 lbs. of milk,	test 3.6 per cent,	=0.9 lb. of butter fat.
Cow No. 2, yield	6 lbs. of milk,	test 5.0 per cent,	=0.3 lb. of butter fat.
Total	31 lbs.	2)8.6	1.2 lbs.
		4.3 per cent	

The two cows gave 31 lbs. of milk containing 1.2 lbs. of fat; the test of the mixed milk would therefore not be 4.3 per cent. $\left(\frac{3.6+5.0}{2}\right)$, but $\frac{1.2\times100}{31}=3.87$ per cent. If the fat in the mixed milk was calculated by the average figure 4.3 per cent., 1.33 lbs. of fat would be obtained, i. e., 0.13 lb. more than the cows produced.

In order to further demonstrate the actual composition of the mixed milk of the twenty-one cows, the milk of each cow was weighed and tested at each of the two milkings of one day. The weights and tests showed that the cows produced the following total number of pounds of milk and of fat:

Morning milking, 113.3 lbs. of milk, containing 5.17 lbs. of fat.
Night milking, 130.9 lbs. of milk, containing 4.98 lbs. of fat.

The morning milk therefore contained $\frac{5.16\times100}{113.3}=4.56$ per cent. of fat, and the night milk, $\frac{4.98\times100}{130.9}=3.80$ per cent. of fat.

The sum of the morning and night milkings gave: milk, 244.2 lbs., fat 10.15 lbs. The mixed morning and night milk, therefore, contained $\frac{10.15\times100}{244.2}=4.1$ per cent. of fat. This is the true average test of the morning and night milkings of these twenty-one cows, as found by weighing and testing separately the milk of each cow at both milkings.

The total milk was strained into a large can at the farm, both in the morning and in the evening. A sample of the mixed milk was in each case taken with a long-handled dipper as soon as the milkings were finished. When the cans of milk were deliv-

ered at the creamery, a sample of each was taken with a Scovell sampling tube. The tests of these four samples are given below, together with the results of the individual tests:

	Morning Milk	Night Milk
Sample taken at the farm, with dipper	4.4 per cent.	3.8 per cent.
Sample taken at creamery with Scovell tube	4.5 "	3.7 "
Calculated from weights and tests of milk from each cow	4.5 "	3.8 "

The figures given show that practically uniform tests were obtained by the different methods of sampling.

Questions.

1. What is a composite sample of milk?

2. Describe the proper care of composite samples.

3. Give an example showing that composite samples of milk may be inaccurate when taken with a small dipper.

4. Describe the following methods of sampling milk or cream, by (a) drip sample, (b) the Scovell, (c) the McKay, and (d) the Michels' sampling tubes.

5. What is the purpose of adding preservatives to milk or cream samples? Mention the more common preservatives used and quantities to be added.

CHAPTER XI.

CREAM TESTING AT CREAMERIES.

200. The cream delivered at gathered-cream factories is now tested by the Babcock test in many localities, and this has been adopted as a basis of paying for the cream in the same manner as milk is paid for at separator creameries, except that tests are made of each lot of cream and not of composite samples. This method has now largely replaced those formerly used for this purpose, such as the oil-test churn or the space (or gauge) system.

The details of the application of the Babcock test to the practical work at cream-gathering creameries have been carefully investigated by Winton and Ogden,[1] Bartlett,[2] Lindsay,[3] and Hunziker.[4]

201. The space system. The space is the volume of a cylinder, 8½ inches in diameter and $\frac{19}{64}$ of an inch high. The number of spaces in each can of milk is read off before skimming by means of a scale marked on a strip of glass in the side of the can. Numerous tests have shown that one space or gauge of cream does not contain a definite, uniform amount of fat. In over 100 comparisons made by Winton it was found that one space of cream[5] contained from .072 to .170 lb. of butter

[1] Conn. experiment station (New Haven), bull. 108 and 119; report 1894, pp. 214-244.

[2] Maine experiment station, bull. 3 and 4 (S. S.)

[3] Hatch experiment station, report 1894, pp. 92-103; 1895, pp. 67-70.

[4] Indiana experiment station, cir. 42.

[5] Conn. exp. sta., bull. 119.

fat, or on the average .13 lb., and the number of spaces required to make one pound of butter varied from 5.01 to 11.72. It is also claimed that in the winter season when cream is gathered at long intervals, like once a week, it is necessary for the buyer to accept the seller's statement of the record of the number of cream spaces which he furnishes, since the cream cannot be left in the creaming can for so long a time. These objections to the space system apply only to the method of paying for the cream, and not to the manner in which the cream is obtained.

202. The oil-test churn. As stated in the introduction, the *oil-test churn* (fig. 56) was formerly used quite extensively among gathered-cream factories; this system is based on the number of inches of cream which the various patrons deliver to the factory; a *creamery inch* is the quantity of cream which will fill a can twelve inches wide, one inch high; it contains 113 cubic inches.[1] This quantity was supposed to make one pound of butter.

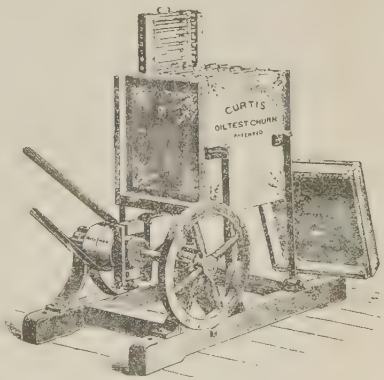

FIG. 56. The oil-test churn.

In using this method the driver pours the patron's cream into his 12-inch gathering pail, measures it with

[1] A layer of two inches in an 8-inch pail contains 100.531 cubic inches, two inches in a 8⅜-inch pail 110.18 cubic inches, and two inches in a 8½-inch pail 113.49 cubic inches.

his rule and records the depth of the cream in the can, in inches and tenths of an inch. The cream is then stirred thoroughly with a ladle or a stout dipper, and sampled by filling a test tube to the graduation mark by means of a small conical dipper provided with a lip. A driver's case contains either two or three "cards," holding fifteen test tubes each (see fig. 57) The tubes as filled are placed in the case and the corresponding number in each instance recorded in front of the patron's name, together with the number of inches of cream furnished by him.

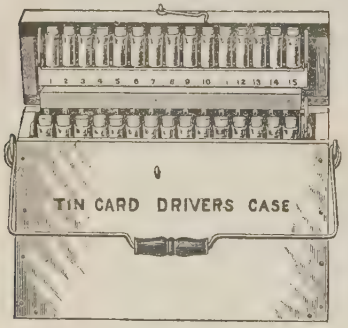

FIG. 57. Cream-gatherer's sample case.

On the arrival at the creamery the tin cards holding the tubes are placed in a vessel filled with water of the churning temperature (say, 60° in summer and 65° to 70° in winter). When ready for churning they are placed in the oil-test churn (fig. 56), the cover of the churn put on, and the samples of cream churned to butter. On the completion of the churning, the cards are transferred to water of 175-190° Fahr., where they are left for at least ten minutes to melt the butter and "cook the butter milk into a curd." The oil will now be seen mixing through the mass. The test tubes are then cooled to churning temperature and churned again, by which process the curd is broken into fine

particles, which, when the butter is re-melted, will settle to the bottom. The butter is melted after the second churning by placing the tubes in water at 150-175° F., allowing them to remain therein for at least twenty minutes. Some samples must be churned three or four times before a good separation of oil is obtained. A clear separation of oil is often facilitated by adding a little sulfuric acid to the tubes.

The length of the column of liquid butter fat is determined by means of a special rule for measuring the butter oil; this rule shows the number of pounds and tenths of a pound of butter which an inch of cream will make; the first tenth of a pound on the rule is divided into five equal parts, so that measurements may be made to two-hundredths of a pound. The melted fat is measured with the rule, by raising the tin card holding the bottles to about the height of the eye; the reading is recorded on the driver's tablet under *Test per inch,* opposite the number of the particular patron. The test multiplied by the inches and tenths of an inch of cream supplied will give the amount of butter in pounds, with which the patron will be credited on the books of the creamery.

203. The objection to this system of ascertaining the quality of cream delivered by different patrons lies in the fact that it determines the *churnable* fat, and not the *total* fat of the cream; the amount of the former obtained depends on many conditions beyond the control of the patron, viz., the consistency, acidity and temperature of the cream, the size of the churn or churn-

ing vessel, etc.[1] The same reasons which caused the churn to be replaced by methods of determining the total fat of the milk, in the testing of cows among dairymen and breeders, have gradually brought about the abandonment of the oil test in creameries and the adoption of the Babcock test in its place.

204. The Babcock test for cream. Both the space system and the oil-test churn used for estimating the quality of cream at creameries have now largely been replaced by the Babcock test in the creameries in this country. On account of the great variation in both the richness and the acidity of farm separator cream it has been found in practice that composite samples of cream are not so satisfactory to either buyer or seller as the testing of a sample taken from each lot of cream gathered.

The following method of collecting and sampling cream is now commonly used by creameries. The cream gatherer who collects the cream in large cream cans is supplied with a spring balance (1, see fig. 58), a pail for sampling and weighing the cream (2), sampling tube (3), collecting bottles (5), and a record book. At each patron's farm he takes from his wagon the sampling pail and tube, the scales, and one small collecting bottle. He should find in the dairy of the patron the cans of perfectly sweet cream, kept at a temparature of 40 to 50 degree F., and protected from dirt and bad

[1] It follows from this that there can be no definite relation between the results obtained by the Babcock test and the oil-test readings; a reading of 100 in the oil-test is, however, on the average, equivalent to about 23 per cent. of butter fat in the cream.

odors. The gatherer hangs the scale on a hook near the cream to be collected; the scale should be made so that the hand of the dial will stand at zero when the empty pail is hung on it. The cream is then poured at least twice from one can to another in order to mix it thoroughly.[1]

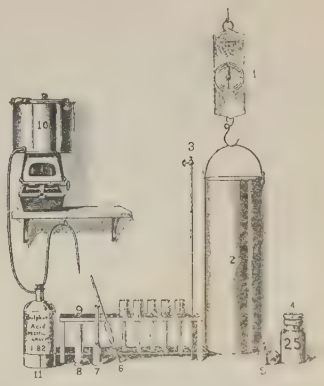

FIG. 58. Outfit for cream testing by the Babcock test at gathered-cream factories.

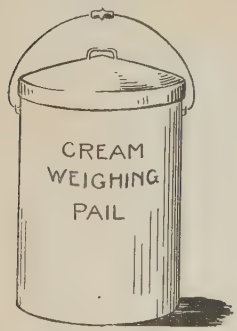

FIG. 58a. Cream weighing pail.

205. Thin, sweet cream is comparatively easy to mix, either by pouring or by using a tin stirrer attached to an iron rod about two feet long. Many lots of cream, however, are thick and sour when the cream gatherer collects them, and satisfactory samples can only be obtained by repeated mixing by pouring; in some cases it is necessary to warm the cream and even to pour it through a strainer to get a uniform mixture.

[1] The necessity of care in mixing the cream is shown by the following illustration given by the authors referred to.

Per cent of fat in cream which stood for 24 hours.

	Surface.	Bottom.	Sample drawn with sampling tube.
Not mixed	28.00	5.00	19.25
Poured once	23.75	22.00	22.50
Poured twice	----	----	22.25

FIG. 58b. Cream sample bottles.

After mixing as well as possible, each lot of cream is poured into the cream-weighing pail (Fig. 58a), from which a sample for testing is taken by means of a sampling tube of about one-half inch diameter. This tube is emptied into a numbered bottle (Fig. 58b) in which the cream is kept until tested. The weighing pail is sometimes cleaned after emptying, by using a rubber scraper and the tube must be completely drained and cleaned before another lot of cream is sampled. A combined stirrer and sampler is sometimes used instead of the sampling tube.

206. The samples of cream in the small bottles, besides furnishing the means of testing the richness of the cream, give the creamery man an opportunity to inspect the flavor of each lot of cream, and the condition in which this has been kept by the various patrons. If the cream samples are tested soon after being collected no preservative is needed and the cream left after filling the test bottles may be saved, but if the samples must be kept sometime before testing, a small quantity of some preservative (193) should be added to the samples to keep them in as good condition as possible until they are tested.

The samples are tested by weighing either 9 or 18 grams of the carefully mixed sample into cream-test bottles, as explained in chapter IV (91).

207. The collecting bottles should be cleaned with cold, and afterwards with hot water, as soon as they are emptied, and before a film of cream dries on them. When washed and dried, these bottles are placed in the cases, ready for the next collecting trip.

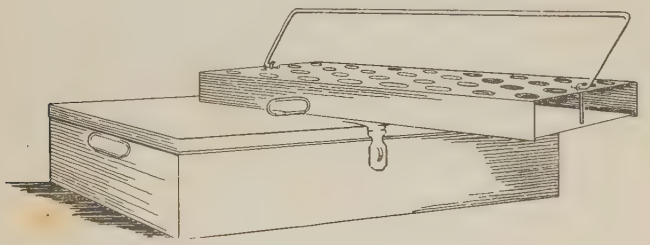

FIG. 58c. Cream sample bottle case.

208. When this system of testing cream samples is adopted, the patrons are paid for the number of pounds of butter fat contained in their cream, in the same way as milk is paid for at separator creameries. It makes no difference how thick or how thin the cream may be, or how much skim milk is left in the cream when brought to the factory. Eighty pounds of cream containing 15 per cent. of fat is worth no more nor less than 48 pounds of cream testing 25 per cent.; in either case 12 pounds of pure butter fat is delivered. This will make the same amount of butter in either case, viz., about 14 lbs., and both patrons should therefore receive the same amount of money.

There is a small difference in the value of the two lots of cream to the creamery owner or the butter maker, in favor of the richer cream, both because its smaller bulk makes the transportation and handling expenses lighter, and because slightly less butter fat will be lost in the butter milk, a smaller quantity of this being obtained from the richer cream.

209. Small differences in the composition of cream will, however, always occur, even if the same system of creaming the milk, like the centrifugal process, is used and all factors remain as nearly the same as possible at all times. This is due to differences in the composition of the milk and its creaming quality; whether largely from fresh cows or from late milkers; whether kept standing for a time before being set, or submerged in the creamer immediately after milking and straining, diameter of creaming cans, etc. Bartlett states[1] that the percentage of fat in the cream from the same cows may be increased ten per cent. or more by keeping the water at 70° instead of at 40° F. The higher temperature will give the richer cream, but the separation will not be so complete, since a richer skim milk is obtained from the milk set at this temperature.

Separator cream is not materially influenced by the conditions mentioned, but even though the separator can be regulated to deliver cream of nearly uniform richness from all kinds of sweet milk, considerably var-

[1] Bull. 3 (S. S.), Maine experiment station.

iations in the richnes of the cream from the same farm may occur because of variations: 1, in the speed of the separator bowl; 2, the temperature of the milk; 3, the rate of the flow of milk into the separator bowl, and 4, the amount of water or skim milk used to flush out the bowl when through skimming.

210. At creameries where both milk and cream are delivered, somewhat of an injustice is done to patrons delivering cream, by paying for the amounts of butter fat furnished by the different patrons, since the milk patron receives pay for all the fat in the milk including that in the skim milk. By multiplying the cream fat by 1.03,[2] the value of his products to the creamery is taken into proper account, and justice is done to all parties concerned[3] (239).

211. Gathering and sampling hand-separator cream. A still more satisfactory method is to provide separate cans for each patron, the cream gatherer leaving an empty, clean can at each farm and taking a full or partially filled can of cream from the farm to the factory. This makes it necessary for the cream gatherer to carry as many cans as he has patrons to gather cream from, but it gives the factory operator a chance to inspect, weigh and sample the cream from each farm

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[2] Spillman (Dairy and Creamery, Chicago, April 1, 1899) recommends the use of the factor 1.044.

[3] This subject is discussed in detail in the 17th annual report of Wis. experiment station, pp. 90-92; see also the 20th report of that Station, pp. 130-31.

and relieves the cream gatherer of all these details which are often the cause of dissatisfaction.

Questions.

1. In what ways do the results obtained with the oil-test churn differ from those obtained with the Babcock test?

2. Describe the method of testing cream by the Babcock test at gathered-cream factories.

3. What advantages has the gathering of cream in separate cans over mixing the cream from all the patrons of one route?

CHAPTER XII.

CALCULATION OF BUTTER- AND CHEESE YIELD

A.—Calculation of Yield of Butter.

212. Butter-fat test and yield of butter. The Babcock test shows the amount of pure butter fat contained in a sample of milk, cream or other dairy products. The butter obtained by churning cream or milk contains, in addition to butter fat, a certain amount of water, salt and curd. While an accurate milk test gives the total quantity of butter fat found in the sample of milk or cream tested, the churn cannot be depended upon either to leave the same amount of butter fat in the butter milk or to include the same amount of water, salt or curd in the butter at each churning.

If a quantity of milk, say 3,000 lbs., be thoroughly mixed in a vat, and then divided into half a dozen equal portions, a Babcock test of the different lots will show the same percentage of butter fat in each portion. If, on the other hand, each of these lots be skimmed, and the cream ripened in different vats and churned separately, the same weight of butter from each lot of 500 lbs. of milk will not be obtained, even by the most expert butter maker, or if all the operations of skimming, cream ripening, churning, salting and butter-working were made as nearly uniform as possible. Careful operators can handle the milk and cream so that very nearly the

same proportion of fat contained in the milk is recovered in the butter in different churnings, but since the water and salt in butter are held mechanically and are not chemically combined with it, the amounts retained by the butter are quite variable in different churnings.

213. Variations in the composition of butter. As an illustration of the variations in the composition of butter that usually occur, the analyses made in the breed tests at the World's Fair in 1893 may be here cited; the butter was in all cases made by as nearly identical methods and under as uniform conditions as could possibly be obtained by the skilled operators having this work in charge; the average composition of 350 samples of this butter, with upper and lower limits, was as shown in the following table:

Composition of samples of butter, World's Fair, 1893.

	Water	Fat	Curd	Salt and ash	Sum of water, curd, salt and ash
	Per cent	Per cent	Per cent	Per cent	Per cent
Average of 350 analyses	11.57	84.70	.95	2.78	15.30
Lower and upper limits	8.63–15.00	76.53–88.26	.50–2.14	1.01–8.58	

Analyses of fifty samples of creamery butter taken in 1896, from the tubs ready for market at as many Wisconsin creameries, showed that no two of them were exactly alike in composition, but varied within the limits given on the following page:[1]

[1] Wisconsin experiment station, bull. 56.

Summary of analyses of Wisconsin creamery butter.

	Water	Fat	Curd	Salt and ash	Sum of water, curd, salt and ash
	Per cent	Per cent	Per cent	Per cent	Per cent
Highest	17.03	87.50	2.45	4.73	22.95
Lowest	9.18	77.07	.36	1.30	12.50
Average	12.77	88.03	1.28	2.87	16.92

The preceding analyses show the composition of butter made at one place where every possible effort was taken to produce a uniform product, and of butter made at fifty different creameries, where there was more or less variation in the different operations of manufacture and in the appliances and machinery used. The majority of the samples of butter analyzed, in either case, were very near the average composition given, but since there are such wide variations in the composition of the butter made by the uniform methods adopted in the World's Fair breed tests, butter of a more uniform composition cannot be expected from the thousands of different creameries and private dairies which supply the general market with butter.

The analyses of the fifty samples of creamery butter, given above, show that the content of the butter fat varied from 77 to 87.5 per cent., and according to the average of the analyses, 83 pounds of butter fat was contained in, or made, 100 lbs. of butter. There was, therefore, in this case produced 20.5 per cent. more butter than there was butter fat, since

$$83 : 100 : : 100 : x; \text{ therefore}$$

$$x = \frac{100 \times 100}{83} = 120.5.$$

214. "Overrun" of churn over test. The yield of butter is not, however, as a rule compared with the amount of butter fat contained in the butter, but with the total butter fat of the whole milk or cream from which it was made. This "increase of the churn over the test" is what is generally called *overrun* in creameries.

The overrun obtained in different creameries, or even in the same creameries at different times, will be found to vary considerably. When the milk is accurately tested and the butter well worked, this overrun will vary from 10 to 16 per cent.; that is, if a quantity of milk contains exactly 100 lbs of butter fat, as found by the Babcock test or any other accurate method, from 110 to 116 lbs. of butter ready for market will be obtained from it. The overrun from cream will be somewhat larger, 18 to 22 per cent., but will never exceed 25 per cent., unless the butter contains less than 80 per cent. fat (217).

215. Factors influencing the overrun from milk. Even under the very best of care and attention to details, variations will occur in the speed of the separator, in the conduct of the ripening and churning processes, in the condition of the butter when the churn is stopped; and in the manner of working the butter; hence absolutely uniform losses of fat in skim milk and butter milk, or the same water- and salt contents of the butter, cannot be expected.

The overrun in separator creameries is influenced by two legitimate factors: *first*, the losses of butter fat sustained in separating the milk and churning the cream, and *second*, the gain due to the admixture of water,

salt, etc., in the manufacture of butter. Considering first the losses of fat in skim milk and butter milk, the separator will usually, when run at normal speed and capacity, leave the same per cent. of fat in skim milk, whether rich or poor milk is skimmed. An exception to this may be found in separating rich milk having large fat globules, or milk from fresh milkers, in either of which cases the large size of the fat globules occasions a more complete separation of fat by the centrifugal force. But generally speaking, the statement holds good that the total loss of fat in separator skim milk is a factor of the quantity of milk run through the separator, rather than of its quality.

216. The losses from poor, rich and average milk, as received at creameries and cheese factories, can be traced from the following statement; this gives the quantities of fat lost in handling milk of four grades, viz.: 2.5, 3.5, 4.0 and 6.0 per cent., in case of each grade calculated to a standard of 100 lbs. of fat in the milk.

To supply 100 lbs. of fat would require the following amounts of the different grades of milk:

4000	lbs.	of	milk	testing	2.5	per	cent	will	contain	100	lbs. of fat.
2857	"	"	"		3 5	"	"	"		100	" " "
2500	"	"	"		4.0	"	"	"		100	" " "
1666	"	"	"		6.0	"	"	"		100	" " "

Assuming that the skim milk contains .1 per cent. of fat and makes up 85 per cent. of the whole milk, and that the butter milk tests .3 per cent., and forms 10 per cent. of the whole milk, the butter-fat record of the quantities of different grades of milk containing 100 lbs. of fat will be as given in the following table. Cer-

tain mechanical losses are unavoidable in the creamery, as in all other factory operations, viz., milk and cream remaining in vats and separators, butter sticking to the walls of the churn, etc. These losses have been found to average about 3 per cent. of the total fat in the milk handled, under normal conditions and under good management (219).

Fat available for butter in different grades of milk.

Grade of milk	Whole milk	Skim milk	Butter milk	Waste	Total loss	Fat available for butter
				Lbs.	Lbs.	Per ct.
2.5 per cent	4000 lbs. 2.5 per ct.	3400 lbs. .1 per ct.	400 lbs. .3 per ct.			
Fat	100 lbs.	3.4 lbs.	1.2 lbs.	3.0	7.6	92.4
3.5 per cent	2857 lbs. 3.5 per ct.	2429 lbs. .1 per ct.	286 lbs. .3 per ct.			
Fat	100 lbs.	2.4 lbs.	.9 lbs.	3.0	6.3	93.7
4.0 per cent	2500 lbs. 4 per ct.	2125 lbs. .1 per ct.	250 lbs. .3 per ct.			
Fat	100 lbs.	2.1 lbs.	.7 lb.	3.0	5.8	94.2
6.0 per cent	1666⅔ lbs. 6 per ct.	1417 lbs. .1 per ct.	167 lbs. .3 per ct.			
Fat	100 lbs.	1.4 lbs.	.5 lb.	3.0	4.9	95.1

The table shows that with 2.5 per cent.-milk, there is a loss of 3.4 lbs. of fat in the skim milk, a loss of 1.2 lbs. of fat in the butter milk, and of 3.0 lbs. in the creamery waste, for every 100 lbs. of fat in the whole milk, or a total loss of 7.6 lbs. from these sources. In case of 6 per cent. milk these losses are 1.4 lbs., .5 lb. and 3.0 lbs. for skim milk, butter milk and waste, respectively; a total loss of 4.9 lbs., or 2.7 lbs. less than the losses with poor milk. This difference in the losses

shrinks to only .5 pound of fat in case of 3.5 and 4.0 per cent.-milk, when a quantity containing 100 lbs. of fat is handled in both cases.

The overrun from each of the four grades of milk can be calculated for butter containing a certain per cent. of fat. Assuming the fat content of butter to be 83 per cent. on the average (213), the quantity of butter obtained from the 100 lbs. of fat, or rather from the portion thereof which is available for butter, in each case will be as follows:

100 lbs. of fat from	Available fat	Butter cont. 83 per ct. fat	Overrun
	Lbs.	Lbs.	Per ct.
4,000 lbs. of 2.5 per cent milk	92.4	111.3	11.3
2,857 lbs. of 3.5 per cent milk	93.7	113.0	13.0
2,500 lbs. of 4.0 per cent milk	94.2	113.5	13.5
1,666 lbs. of 6.0 per cent milk	95.1	114.6	14.6

The overrun figures given above may be increased by saving some of the three pounds of butter fat lost by waste. If it were possible to entirely eliminate this loss there would be three pounds more available fat in each case, viz., 95.4, 96.7, 97.2, 98.1 lbs. These amounts of fat will make 115, 116.5, 117.1, and 118.2 lbs. butter, corresponding to an overrun of 15, 16.5, 17.1, and 18.2% from milk of the different fat contents mentioned.

All butter makers should obtain more butter from a certain quantity of milk than the Babcock test shows it to contain butter fat, but it is impossible to know exactly, except by chemical analysis, how much butter fat is lost in the skim milk and the butter milk, and how much water, salt and curd the butter will contain. A

butter maker's skill is shown by his ability to reduce the losses by waste in handling the milk, cream and butter, as well as the losses of butter fat in skim milk and butter milk, and his carefulness in weighing, sampling and testing the milk, cream and butter made.

217. Overrun from cream. The overrun from cream is, as already stated, larger than from milk because there is no loss of fat in the skim milk to be considered. Rich cream will give a slightly larger overrun than thin cream, for the same reasons as have been shown in the calculations of overrun from milk of different fat contents. If similar calculations are made for cream of different richness as those given above for milk, the fat available for butter-making and the yield of butter per 100 pounds of fat in the cream will be as shown below. A mechanical loss in the process of butter-making amounting to 2 per cent. has been assumed in these calculations:

100 lbs. fat in cream	Available fat	Butter of 83 per ct. fat	Overrun
Per cent	Lbs.	Lbs.	Per cent
20	96.8	116.6	16.6
30	97.3	117.2	17.2
40	97.6	117.6	17.6

We note that the overrun for cream of different quality under the conditions given ranges from 16.6 for 20-per cent. cream to 17.6 for 40-per cent. cream. A somewhat larger overrun would be obtained when the butter made contains less fat and more water than assumed.

If no losses from waste are considered in the account, the figures for fat available for butter will be 98.8, 99.3,

and 99.6 lbs., and the overruns when the butter contains 83% fat will be 19, 19.3, and 20 per cent. These overruns are higher than will be obtained under ordinary creamery conditions with butter containing 83.0% fat, because it is impossible to reduce the manufacturing losses in handling the cream and butter appreciably below 2 per cent.

217a. Maximum overrun for butter of a legal water content. If we assume that the butter contains the maximum amount of water allowed by law, viz., 16 per cent. (and therefore about 80 per cent. fat), the overrun for both milk and cream would be somewhat larger than already given, as shown by the following figures:

Maximum overrun from milk		Maximum overrun from cream.	
2.5%	15.5	20%	21.0
3.5%	17.1	30%	21.6
4.0%	17.8	40%	22.0
6.0%	18.9		

This table shows the highest overruns that are likely to be obtained when the butter is to contain no more than the maximum amount of water allowed by law. Larger overruns can only be obtained by reducing the losses of manufacture (which will give but slightly higher figures) or, fraudulently, by inaccurate weighing or testing of the milk, cream or butter.

218. Calculation of overrun. The overrun is calculated by subtracting the amount of butter fat contained in a certain quantity of milk or cream, from the amount

of butter made from it, and finding what per cent. this difference is of the amount of butter fat in the milk.

Example 1: 8000 lbs. of milk is received at the creamery on a certain day; the average test of the milk is 3.8 per cent. By a simple multiplication we find that the milk contained 8000× .038=304 lbs. of butter fat. 350 lbs. of butter was made from this milk, as shown by the weights of the packed tubs. The difference between the weight of butter and butter fat is, therefore, 46 lbs.; 46 is $\frac{46\times100}{304}$ =15.1 per cent. of the quantity of the butter fat in the milk; that is, the overrun for the day considered was 15.1 per cent.

The formula for the *overrun* is as follows:

$$X = \frac{(b-f)100}{f}$$

b and *f* designating the quantities of butter and butter fat, respectively, made from or contained in a certain quantity of milk. In the preceding example, the calculation would be as follows: $\frac{(350-304)\times100}{304}$ =15.1 per cent.

Example 2: 1000 lbs. of cream testing 25 per cent. fat contains 1000×.25=250 lbs. butter fat. If 304 lbs. of butter is made, the overrun may be calculated by subtracting the butter fat from the butter, 304—250=54 lbs., then divide this by the fat in the cream and multiply by 100; or $\frac{54\times100}{240}$ =21.8 per cent., which is the cream overrun.

219. Conversion factor for butter fat. In the ninety-day dairy test at the World's Columbian Exposition, 96.67 per cent. of the fat in the whole milk was recovered in the butter. This butter, on the average, contained 82 37 per cent. butter fat; in other words, 117.3 pounds of butter were made from each 100 pounds of butter fat in the whole milk.[1] The exact conversion factor

[1] When 82.37 lbs. of butter fat will make 100 lbs. of butter, how much butter will 96.67 lbs. of butter fat make? 82.37: 96.67 : : 100: x, x=117.3.

would be 1.173. As this is an awkward number to use, and as 1⅙ is so nearly the same, it was recommended at the time that the approximate equivalent of butter be computed by multiplying the amount of butter fat by 1⅙, and this figure has been generally accepted for computing the yield of butter from a certain amount of butter fat in milk.

The figures given are the result of more than ordinary care in skimming, churning and testing, and probably represent the minimum losses of fat in the manufacturing processes. The increase of churn over test represented by one-sixth, or 16 per cent., may therefore be taken as a maximum "overrun" for milk under ordinary factory conditions.

220. Butter yield from milk of different richness. a. Use of butter chart. The approximate yield of butter from milk of different richness is shown in Table XI in the *Appendix*. This table is founded on ordinary creamery experience and will be found to come near to actual every-day conditions in creameries where modern methods are followed in the handling of the milk and its products. The table has been prepared in the following manner:

It is assumed that the average loss of fat in the skim milk is .20 per cent., and that 85 lbs. of skim milk is obtained from each 100 lbs. of whole milk; to this loss of fat is added that from the butter milk; about 10 lbs. of butter milk is obtained per 100 lbs. of whole milk, testing on the average .30 per cent.

If f designate the fat in 100 lbs. of milk, then the fat recovered in the butter from 100 lbs. of milk will be

$$f-\left(\frac{85}{100}\times.20+\frac{10}{100}\times.30\right)=f-.20$$

There is, on the other hand, an increase in weight in the butter made, owing to the admixture of non-fatty components therein, principally water and salt. Butter packed and ready for the market will contain in the neighborhood of 84 per cent. of fat (214), so that the fat recovered in the butter must be increased by $\frac{100}{84} = 1.19$. If B therefore designate the yield of butter from 100 lbs. of milk, the following formula will express the relation between yield and fat content, provided there are no other factors entering into the problem, viz.:

$$B = (f - .20)\ 1.19$$

From this value for B, should be deducted the loss due to wastes in the manufacturing processes, amounting to 3 per cent. of the total fat in the milk handled, and we therefore have:

$$B = (f - .20)\ 1.16$$

Since this table is based on a fat content of .2 per cent. in the skim milk, the figures for the overrun are slightly lower than may be obtained in creameries provided with up-to-date cream separators.

221. Table XI in the *Appendix,* founded on this formula, may be used to determine the number of pounds of butter which milk containing 3 to 5.3 per cent. fat will be likely to make. It presupposes good and careful work in separating and churning and under such conditions will generally show yields of butter varying but little from those actually obtained. It may be conveniently used by the butter maker or the manager to check up the work in the creamery; the average test of the milk received during a certain period is found by dividing the total butter fat received, by the total milk, and multiplying the quotient by 100; the amount of butter which the total milk of this average fat content will make, according to the table, is then compared with the actual churn yield.

Example: A creamery receives 200,000 lbs. of milk during a month; the milk of each patron is tested and the fat contained therein calculated. The sum of these amounts of fat may be 7583 lbs; the average test of the milk is then 3.79 per cent. According to Table XI, 10,000 lbs. of milk, testing 3.8, will make 418 lbs. of butter, and 200,000 lbs., therefore, 8360 lbs. of butter. The total quantity of butter made during the month will not vary appreciably from this figure if the work in the creamery has been properly done.

222. b. **Use of overrun table.** The table referred to above gives a definite calculated butter yield for each grade of milk, according to average creamery conditions. As it may be found that this table will give uniformly either too low or too high results, Table XII in the *Appendix* is included, by means of which the butter yield corresponding to overruns from 10 to 20 per cent. may be ascertained in a similar way as above described.

The total yield of butter is divided by the total number of pounds of fat delivered; the quotient will give the amount of butter made from one pound of fat, and this figure multiplied by the fat delivered by each patron shows the pounds of butter to be credited to each patron. To use the table, find in the upper horizontal line the number corresponding nearest to the number of pounds of butter from one pound of fat. The vertical column in which this falls gives the pounds of butter from 100 lbs. of milk containing the per cents. of fat given in the outside columns (Babcock).

B.—Calculation of Yield of Cheese.

223. a. **From fat.** The approximate yield of green Cheddar cheese from 100 lbs. of milk may be found by multiplying the per cent. of fat in the milk by 2.7; if *f*

designate the per cent. of fat in the milk, the formula will, therefore, be:

$$\text{Yield of cheese} = 2.7\ f. \quad . \quad . \quad . \quad . \quad . \quad (I)$$

The factor 2.7 will only hold good as the average of a large number of cases. In extensive investigations during three consecutive years, Van Slyke[1] found that the number of pounds of green cheese obtained for each pound of fat in the milk varied from 2.51 to 3.06, the average figures for the three years 1892-'94, inclusive, being 2.73, 2.71, and 2.72 lbs., respectively. The richer kinds of milk will produce cheese richer in fat, and will yield a relatively larger quantity of cheese, pound for pound, than poor milk, for the reason that an increase in the fat content of milk is accompanied by an increase in the other cheese-producing solids of the milk.[2] The preceding formula would not, therefore, be correct for small lots of either rich or poor milk, but only for milk of average composition, and for large quantities of normal factory milk. For cured cheese the factor will be somewhat lower, viz., about 2.6, on the average.

224. b. **From solids not fat and fat.** If the percentages of solids not fat and of fat in the milk are known, the following formula by Babcock will give close results:

$$\text{Yield of green cheese} = 1.58\ \left(\frac{s}{3} + .91f\right) \quad - \quad - \quad (II)$$

[1] N. Y. experiment station (Geneva), bulletins 65 and 82.

[2] Investigations as to the relation between the quality of the milk and the yield of cheese have been conducted by a number of experiment stations; the following references give the main contributions published on this point; N. Y. (Geneva) exp. sta., reports 10-13, incl.; Wis. exp. sta., reports 11, 12, bull. 197, 276; Ont. Agr. College, reports 1894-'96, incl.; Minn. exp. sta., b. 19, reports 1892-'94, incl.; Iowa exp. sta., bull. 21; Hoard's Dairyman, 1892, p. 2400.

s being the per cent. of solids not fat in the milk, and f the per cent. of fat.[1]

The solids not fat can be readily ascertained from the lactometer reading and the per cent. of fat as shown in par. 120, by means of Table VI in the *Appendix.*

Table XIII in the *Appendix* gives the yield of cheese from 100 lbs. of milk containing from 2.5 to 6.0 per cent. fat, the lactometer readings of which range between 26 and 36. By means of this table cheese makers can calculate very closely the yields of cheese which certain quantities of milk will make; as it takes into consideration the non-fatty solids as well as the fat of the milk, the results obtained by the use of this formula will be more correct than those found by means of formula (I). The uncertain element in the formula lies in the factor 1.58, which is based on an average water content of 37 per cent. in the green cheese. This may, however, be changed to suit any particular case, e. g., 35 per cent. ($\frac{100}{65}$=1.54), 40 per cent. $\frac{100}{60}$=1.67, etc. The average percentages of water in green cheese found by Van Slyke in his investigations referred to above, were for the years 1892-'94, respectively, 36.41, 37.05 and 36.70 per cent.

225. c. From casein and fat. If the percentages of casein and fat in the milk are known, the yield of cheese may be calculated by the following formula, also prepared by Dr. Babcock:

Yield of cheese=1.1 f+2.5 casein . . . . (III).

This formula will give fairly correct results, but no more so than formula (II); it is wholly empirical.

[1] For derivation of this formula, see Wisconsin experiment station, twelfth report, p. 105.

Questions.

1. What is the average composition of American creamery butter, and between what extremes does the composition of butter vary?

2. What is the difference between the churn yield and the results obtained by the Babcock test?

3. What does the overrun represent?

4. Mention several factors that cause a large overrun.

5. Give an illustration of how the per cent. of increase of churn over test is found, and how the overrun is calculated.

6. Show by an example that butter containing 80% fat cannot give an overrun of more than 25%.

7. How many pounds of butter containing 80% fat can be made from 100 lbs. fat?

8. Why is the overrun from cream greater than from milk?

9. What is the overrun when 70.5 lbs. of butter are made from 140 lbs. of milk, testing 3.15 per cent?

10. What is the overrun in each of the following cases?
    220 lbs. butter from 8000 lbs. milk, testing 2.3% fat.
    250 lbs. butter from 4000 lbs. milk, testing 5.8% fat.
    600 lbs. butter from 2000 lbs. cream, testing 25.0% fat.
    480 lbs. butter from 1000 lbs. cream, testing 40.0% fat.

11. How much butter containing (a) 80% fat, and (b) 82.5% fat can be made from 3250 lbs. milk, testing 4.3% fat, assuming that the skim milk is 80% of the whole milk and contains 0.1% fat, and the butter milk, which is the cream minus the fat, contains 0.25% fat? What is the overrun in each case?

12. How much butter is obtained from 5800 lbs. milk, testing 3.7% fat, when the overrun is (a) 12.5% and (b) 16%?

13. Two cows in full milk produce, one 17.5 lbs. of milk a day, containing 4.35% fat; the other, 27.3 lbs. of milk, testing 3.4%. If the milk of both is made into butter or cheese, how much butter or cheese may be expected from each one in a week?

14. What is a fair percentage of loss of fat by waste other than in skim milk and butter milk under average creamery conditions in case of milk and cream?

15. How much butter may be made from (a) 15,640 lbs. milk, testing 3.8% fat, and (b) 35,842 lbs. milk, testing 4.1% fat? (Use Table XI, *Appendix.*)

CHAPTER XIII.

CALCULATING DIVIDENDS.

A.—Calculating Dividends at Creameries.

226. The simplest method of calculating dividends at creameries is to base the calculations on the amount of butter fat delivered by the various patrons. Each lot of milk is weighed when delivered at the creamery, and a small quantity thereof is saved for the composite sample, as previously explained under Composite Tests (180). Some creameries test these samples at the end of each week, and others after collecting them for ten days or two weeks. If the four weekly composite samples of a patron's milk tested 3.8, 4.0, 3.9, 4.1 per cent., these four tests are added together, and the sum divided by 4; the result, 3.95 per cent., is used as the average test of this milk. By multiplying the total number of pounds of milk delivered by this patron, by his average test, the total weight of butter fat in pounds delivered to the factory during the month is obtained. This weight of fat is then multiplied by the price to be paid by the creamery per pound of butter fat; the product shows the amount of money due this patron for the milk delivered during the time samples were taken.

227. Price per pound of butter fat. The method of obtaining the price to be paid for one pound of butter fat varies somewhat in different creameries, on account of the different ways of paying for the cost of manu-

facturing the butter. The method to be followed is generally determined by agreement between the manufacturer and the milk producers, in case of proprietary creameries, or among the shareholders, in co-operative creameries. The following methods of paying for the cost of manufacture are at the present time in use in American creameries.

228. I. Proprietary creameries. *First.*—When the creamery is owned by some one person or company, the owner or owners agree to make the butter for about 3 cents a pound; the difference between the total receipts of the factory and the amount due the owner is then divided between the different patrons, according to the amount of butter fat contained in the milk which they delivered.

The price charged for making butter varies from 2½ to 4 cents per pound; the larger the amount of milk received at a factory, the lower will naturally be the cost of manufacturing the butter.[1]

Second.—The proprietor of the creamery sometimes agrees to pay a certain price for 100 lbs. of milk delivered, according to its fat content, the price of milk containing 4 per cent. of butter fat being the standard. This price may be changed during the different seasons of the year by mutual agreement.

Third.—A creamery owner may offer to pay 1 to 2 cents, usually 1½ cents, below the average market price of butter, for each pound of butter fat received in the milk.

[1] Bull. 56, p. 26, Wisconsin exp. station; see Report 18, Iowa State Dairy Commissioner, p. 33.

229. II. Co-operative creameries. Where the creamery is owned by the patrons, one of the stockholders who is elected secretary attends to the details of running the factory and selling the product. His accounts show the amount of money received each month for the butter and other products sold, and the expenses of running the factory during this time. The expenses are subtracted from the receipts, and the balance is divided among the patrons, each one receiving his proportionate share according to the amounts of butter fat delivered in each case, as shown by the total weight and the average test of milk delivered during this time.

In nearly all cases, the farmers receive about eighty pounds of skim milk for each one hundred pounds of whole milk they deliver to the factory, in addition to the amount received for the milk, calculated according to one or the other of the preceding methods.

230. Illustration of calculation of dividends. In order to illustrate the details of calculating dividends, or the amount to be paid each patron for the milk delivered, when payments are made by each of the four systems given, it will be assumed that a creamery receives 5000 pounds of milk daily during a month, and makes 6650 lbs. of butter from the 150,000 lbs. of milk received during this time. The average test of this milk may be found by multiplying the total weight of milk delivered by each patron by his average test, and dividing the sum of these products by the total weight of milk received at the creamery (in the example given, by 150,000), the quotient being multiplied by 100. Such calculations may show that, e. g., 5700 lbs. of butter fat have been received in all the milk delivered by the different patrons; this multiplied by 100 and divided by 150,000 gives 3.8 as the average test, or the average amount of butter fat in each 100 lbs. of milk received during the month.

So far the method of calculation is common for the different systems of payment given above; the manner of procedure now

differs according to the agreement made between owner and patrons, or among the shareholders, in case of co-operative creameries.

231. I. *First.*—If the net returns for the 6650 lbs. of butter sold during the month were $2394, and the creamery is to receive 4 cents per pound of butter as the cost of manufacture, etc., the amount due the creamery is 6650×.04=$266, and the patrons would receive $2394—$266=$2128. This sum, $2128, is to be paid to the patrons for the 5700 lbs. of butter fat, which, as shown above, was the weight of fat contained in the 150,000 lbs. of milk delivered during the month. The price of one pound of butter fat is then easily found: $2128÷5700=37⅓ cents. This price is paid to all patrons for each pound of butter fat delivered in their milk during the month. The monthly milk record of three patrons may, e. g., be as given in the following table:

Pat on	First week		Second week		Third week		Fourth week		Total Milk	Average test
	Milk	Test	Milk	Test	Milk	Test	Milk	Test		
	Lbs.	%	Lbs.	%	Lbs.	%	Lbs.	%	Lbs.	%
No. 1	3500	3.6	3000	3.5	3600	3.65	3450	3.45	13,550	3.55
No. 2	700	3.8	665	3.8	720	3.6	750	3.7	2.825	3.73
No. 3	2480	4.2	2000	3.8	1850	4.0	1500	3.6	7,830	3.90

Multiplying each patron's total milk by his average test gives the number of pounds of butter fat in his milk, and this figure multiplied by .37⅓ shows the money due for his milk, as given below:

Patron	Total milk	Average test	Butter fat	Price of fat per lb.	Amount due
	Lbs.	Per cent	Lbs.	Cents	
No. 1	13,550	3.55	481.0	37⅓	$179.41
No. 2	2,835	3.7	104.5	37⅓	38.98
No. 3	7,830	3.9	305.4	37⅓	113.91

232. *Second.*—When the proprietor of a creamery agrees to pay a certain price for 100 lbs. of 4 per cent. milk, the receipts for butter sold and the price per pound of butter do not enter into the calculation of the amount due each patron for his milk;

but the weight and the test of each patron's milk are as important as before. If it is agreed to pay $2.50 per 100 lbs. of 4 per cent. milk (i. e., milk containing 4 per cent. of butter fat), the price of one pound of butter fat will be $2.50 ÷ 4 = 62.5 cents, and the amount due each patron is found by multiplying the total weight of butter fat in his milk by this price. To facilitate this calculation, so-called *Relative-Value Tables* have been constructed, the use of which is explained below (238).

233. *Third.*—If a creamery agrees to pay for butter fat, say 1 cent per pound below the average market price of butter each month, the price of one pound of butter fat is found by averaging the market quotations and subtracting 1 cent therefrom. If the four weekly market prices were 37, 38, 37 and 40 cents, the average of these would be 38 cents, and this less 1 cent gives 37 cents as the price per pound of fat to be paid to the patrons; this price is then used in calculating the dividend as in case of first method.

Patron	Total milk	Average test	Butter fat	Price of fat per lb.	Amount due
	Lbs.	Per cent	Lbs.	Cents	
No. 1	13,550	3.55	481.0	37	$177.97
No. 2	2,825	3.7	104.5	37	38.67
No. 3	7,830	3.9	305.4	37	113.00

234. II. If the creamery is owned by the farmers, the running expenses for a month are subtracted from the gross returns received for the butter, and the price to be paid per pound of butter fat is found by dividing the amount left by the total number of pounds of butter fat delivered during the month. This price is used for paying each patron for his milk according to the amount of fat contained therein, as already explained under *Proprietary Creameries* (231).

The monthly running expenses of a co-operative creamery generally include such items as the wages of the butter maker (and manager or secretary, if these officers are salaried), labor (hauling, helper, etc.), cost of butter packages, coal or wood, salt and other supplies, freight and commission on the butter sold, repairs and insurance on buildings, etc. A certain amount is also paid into a *sinking fund* (say, 5 cents per 100 lbs. of milk),

which represents the depreciation of the property, wear and tear of building and machinery, bad debts, etc. These items are added together, and their sum subtracted from the gross receipts for the butter sold during the month.

235. Assuming the receipts for the butter during the month to be $2394, and the running expenses of the factory $285, the amount to be divided among the patrons is $2109; the quantity of butter fat received was 5700 lbs., and the price per pound of butter fat will therefore be 37 cents. The account will then stand as given in (233).

236. Other systems of payment. Besides these four systems of payment, there are various other agreements made between manufacturer and producer, but with them all the one important computation is the price to be paid per pound of butter fat; this forms the basis of calculating the factory dividends, when milk is paid for by the Babcock test.

237. Paying for butter delivered. In some instances patrons desire to receive pay for the quantity of butter which the milk or cream delivered by them would make This can be ascertained quite satisfactorily from the total receipts and the total weights of both butter fat and butter. The total money to be paid for butter (the net receipts) are divided by the number of pounds of butter sold, to get the price to be paid per pound of butter; the total yield of butter divided by the total amount of butter fat delivered in the milk, gives the amount of butter corresponding to one pound of butter fat, and the number of pounds of fat delivered by each patron is then multiplied by this figure. This method requires more figuring than those given in the preceding, and the dividends are no more accurate, in fact less so, than when calculations are based on the price per pound of fat.

237a. Making butter "for the overrun." When cream is bought on the basis of paying the market price of butter for each pound of butter fat in the cream, the margin received by the cream buyer, if he makes this cream into butter, is influenced both by the price of butter and the per cent. of overrun he obtains. If the price of butter is 20c. and the overrun is 20%, each pound of butter fat makes 1.2 lbs. of butter, and the buyer receives 24 cents for the butter, or 4 cents margin on the 1.2 lbs. of butter made, which is equal to 3⅓ cents per pound of butter. If the price of butter is 36 cents, and the overrun 20%, the cream buyer receives 1.2×36=43 cents for the butter, or 7 cents for 1.2 lbs. of butter, equivalent to 5.8 c. per pound of butter.

238. Relative-value tables. These tables give many of the multiplications used in computing the amount due for various weights of milk of different fat contents. They can easily be constructed by any one as soon as the price of one pound of fat is determined in each case. If the price to be paid per pound of fat is, say 25 cents, the value of each 100 lbs. of milk of different quality is found by multiplying its test by 25. If the average tests of the different patrons' milk vary from 3 to 5 per cent., the relative-value table would be as follows.

3.0×25=75c. per 100 lbs.	3.6×25=90c. per 100 lbs.
3.1×25=77.5c. "	3.7×25=92.5c. "
3.2×25=80c. "	3.8×25=95.0c. "
3.3×25=82.5c. "	3.9×25=97.5c. "
3.4×25=85.0c. "	4.0×25=100c. "
3.5×25=87.5c. "	etc.

By continuing this multiplication, or adding the multiplier each time for each tenth of a per cent. up to 5

per cent. of fat, a table is made that can be used for calculating the amount due per 100 lbs. of milk at the price per pound given, and the weight of milk delivered by each patron is multiplied by the price per 100 lbs. of milk shown in the table opposite the figure representing his test.

Example: A patron supplies 2470 lbs. of milk, testing 3.2 per cent. of fat; price per pound of fat, 25 cents; he should then receive 24.70×.80=$19.76 (see above table). Another patron delivering 3850 lbs. of milk testing 3.8 per cent. will receive, at the same price per pound of fat, 38.50×.95=$35.57.

The relative-value tables in the *Appendix* give the price per 100 lbs. of milk testing between 3 and 6 per cent. fat, when the price of three per cent. milk varies from 30 to 90c. per 100 lbs. In using the tables, first find the figure showing the price which it has been determined to pay for 100 lbs. of milk of a certain quality, say 3 or 4 per cent.-milk; the figures in the same vertical column then give the price to be paid per 100 lbs. of milk testing between 3 and 6 per cent.

Example 1: It has been decided to pay 90 cents per 100 lbs. of 4 per cent.-milk. The figure 90 is then sought in the table in the same line as 4.0 per cent., and the vertical column in which it is found gives the price per 100 lbs. of 3 to 6 per cent.-milk; 3.8 per cent.-milk is thus worth 85 cents per 100 lbs. and 4.5 per cent.-milk, $1.01, under the conditions given. The prices of milk of other qualities are found in the same way.

Example 2: In the example referred to under Illustrations of calculating creamery dividends (I b, 231), the figures for the patrons Nos. 1, 2 and 3, would be as follows:

Patron	Milk delivered	Average test	Price per 100 lbs. of milk	Amount due
	Lbs.	Per cent	Cents	
No. 1	13,550	3.55	58.5	$79.26
No. 2	2,825	3.7	61.1	17.23
No. 3	7,830	3.9	64.0	50.11

239. Milk- and cream dividends. When cream from farm hand separators or other sources is brought to a factory receiving and skimming whole milk, the cream patron's dividend should be calculated a little differently than that of the milk patron (210).

In one case the dividend is based on the weight and the test of cream and in the other on the weight and the test of milk; the difference between the two being represented by the fat left in the factory skim milk. This skim milk fat is included in the milk patron's dividend and consequently ought also to be allowed for in calculating the amount due the cream patron. Such an allowance can be fairly made by multiplying the cream fat by 1.03. The amounts of fat thus obtained represent very nearly the fat in the milk from which the cream was skimmed and assumes that the fat returned to the milk patron in his skim milk is about three per cent. of the total fat in his whole milk.

Since both milk and cream patron suffer the same manufacturing losses in the butter milk, an equalization of the skimming losses is all that is necessary in order to put both on a uniform basis for calculating dividends.

240. The following illustration will help to make these calculations clearer. Milk patron No. 1 delivers to the creamery during the month 5320 lbs. of milk testing 3.8 per cent. fat, which therefore contains $\left(\frac{5230\times3.8}{100}\right)=202$ lbs. butter fat. If the price paid the patrons is 20c., then 202 multiplied by 20 amounts to $40.40, the money due this patron for his milk. If another patron sent 485 lbs. of cream testing 22.0 per cent. fat to the same factory during the month, the weight of fat in the cream is first found in the same way as in the milk. $\left(\frac{485\times22}{100}\right)=106.7$ lbs. but

ter fat. Now, instead of multiplying this butter fat by 20c., as was done for the whole milk patron, it must first be multiplied by 1.03. 106.7×1.03=109.9 lbs. butter fat which is now multiplied by 20c. per pound, giving $21.98. This is the amount due the cream patron when both milk and cream are received at the same factory and the cream from both patrons is churned together.[1]

241. The amount of cheese made from a certain quantity of milk depends, as before shown, in a large measure on the richness of the milk in butter fat (223). Rich milk will give more cheese per hundred weight than poor milk, and within the ordinary limits of normal factory milk the increased yields will be nearly, but not entirely, proportional to the fat contents of the different kinds of milk. Since the quality of the cheese produced from rich milk is better than that of cheese made from thin milk and will demand a higher price, it follows that no injustice is done by rating the value of milk for cheese production by its fat content. This subject was discussed frequently during the nineties in experiment station publications and in the dairy press (223). Among others, Babcock has shown that the price of cheese stands in a direct relation to its fat content.[2] Prof. Robertson, ex-Commissioner of Agriculture of Canada, is authority for the statement that the quality of the cheese made from milk containing 3.0 to 4.0 per cent. of fat was increased in value by one-eighth of a cent per pound for every two-tenths of a per cent. of fat in the milk,[3] a figure which is fully corroborated by

[1] 17th report Wis. exp. station, p. 90; 20th report, pp. 130-131.

[2] Wisconsin exp. station, 11th report, p. 134.

[3] Hoard's Dairyman, March 29, 1895.

Dr. Babcock's results. The injustice of the "pooling system," by which all kinds of milk receive the same price, is evident from the preceding; if the milk of a certain patron is richer than that of others, it will make a higher grade of cheese, and more of it per hundredweight; hence a higher price should be paid for it.

Payment on the basis of the fat content of milk is, therefore, the most equitable method of valuing milk for cheese making, and in case of patrons of cheese factories as with creamery patrons, dividends should be calculated on the basis of the results obtained by testing the milk delivered. The testing may be conveniently arranged by the method of composite sampling, in the way already described for creameries (180).

242. Cheese factory dividends. (a) *Dividends based on fat test alone.* As in the case of creameries, the price to be paid per pound of butter fat must first be ascertained. The factory records should show the number of pounds of cheese made from the total milk delivered to the factory during a certain time, generally one month, and the money received for this cheese. The cost of making the cheese and all other expenses that should be paid for out of the money received for the cheese, are deducted from the total receipts, and the difference is divided among the patrons in proportion to the amounts of butter fat delivered in the milk.

The weights of the milk delivered and the tests of the composite samples furnish data for calculating the quantities of butter fat to be credited to each patron

The money to be paid to the patrons is then divided by the total weight of butter fat delivered to the factory and the price of one pound of fat thus obtained. The money due each patron is now found by multiplying the total number of pounds of butter fat in his milk by this price per pound.

(b) *Dividends based on fat and solids-not-fat* (lactometer readings). A close estimate of the cheese value of each patron's milk may be made, as explained in par. 224, b., by the use of table XIII in the *Appendix*. When the cheese yield of each patron's milk is found by this method, the money to be distributed among the patrons is divided by the sum of the figures found by these two tests, instead of by the total butter fat. The figure thus obtained is the price to be paid each patron per pound cheese that may be made from his milk as shown by both the fat test and the lactometer reading.

(c) *Dividends based on "the fat plus two method."* The money due patrons for milk delivered at cheese factories may be calculated by adding two to the per cent. of fat in the milk, and otherwise proceeding as explained above under par. 242a. This is the method advocated by Prof. H. H. Dean of Guelph (Ont.) Agricultural college.[1] It has been adopted at many Canadian cheese factories and at some factories in this country.

(d) *Dividends based on the fat and casein tests.* The results obtained by the fat test and the Hart casein

[1] Bull. 114, Ont. Agr. College; see also Dean, Canadian Dairying, p. 146, and Sammis, Wisconsin station, bull. 276.

test (258) are added together; the pounds of milk delivered by each patron are multiplied by this figure and the product multiplied by the price to be paid for the sum of the fat and the casein.[1] This price per pound is obtained in the same way as the price per pound of fat. Each patron's milk is multiplied by the sum of the fat and the casein tests and the money to be distributed to the patrons is divided by the sum of these figures obtained for all patrons for the period covered.

The illustrations already given for calculating patrons' dividends at creameries according to the various methods will serve equally well to show the manner in which dividends are calculated at a cheese factory. For the sake of clearness an example is given that applies directly to cheese factories.

243. Illustration of calculation dividends. It may be assumed that 15,000 llbs. of green cheese is made from 150,000 lbs. of milk delivered to a factory in a month. According to the weighings and the tests made, the milk contained 5,700 lbs. of butter fat. If the cheese sold at an average price of 20 cents a pound, the gross receipts would be $3,000. The amount to be deducted from the gross receipts will depend on the agreement made between the factory operator and the patrons, in case of proprietary cheese factories, or between the shareholders and the maker, when the factory is run on the co operative plan. As before we shall consider these systems separately.

244. I. Proprietary cheese factories. The owner of the factory generally agrees to make the cheese for a certain price per pound and to pay the patrons what is left after deducting this amount. If the price agreed on is 2 cents per pound of green cheese, this would amount to $300 in the example given. Subtracting this sum from the gross receipts, $3,000, leaves

[1] Wisconsin expt. station, bull 197.

$2,700 which is to be paid the patrons. The total amount of butter fat delivered by the patrons was 5,700 lbs., hence the price of one pound of butter fat will be 2,700÷5,700=.2111, or 21 cents. Taking the figures for the three patrons already mentioned under Creamery Dividends, we then have:

Patron	Total milk	Average test	Butter fat	Price per lb. of fat	Amount due
	Lbs.	Per cent	Lbs.	Cents	
No. 1	13,350	3.55	481.0	21	$101.01
No. 2	2,825	3.7	104.5	21	21.94
No. 3	7,830	3.9	305.4	21	64.13

245. II. Co-operative cheese factories. The method of payment at co-operative cheese factories is nearly the same as that already given, except that a certain sum representing the expenses is subtracted from the gross receipts for the cheese, and the balance is divided among the patrons according to the amount of butter fat furnished by each, in the same manner as in the above case, after the price of a pound of fat has been obtained.

The price per 100 lbs. of milk can be calculated in the same way as at creameries, by multiplying the test of each lot by the price per pound of fat.[1]

Questions.

1. How much money is due each of three patrons of a creamery when the following weights of milk are delivered by each:

A— 5750 lb. milk, composite tests, 4.0—4.8—4.2 per cent.

B— 955 lb. milk, composite tests, 4.6—5.0—4.8 per cent.

C—10,538 lb. milk, composite tests, 3.2—3.5—3.0 per cent.

(a) When 700 lbs. of butter are sold for $200, and the cost of making is 3½c. per lb;

(b) When the factory agrees to pay $1.00 per 100 lbs. milk, testing 4% fat;

[1] Suggestions regarding the organization of co-operative creameries and cheese factories will be found in the *Appendix*, following Table XV. Draft of constitution and by-laws for co-operative factory associations are also given in the *Appendix*. It is hoped that these will prove helpful to farmers who contemplate forming such associations

CHAPTER XIV.

CHEMICAL ANALYSIS OF MILK AND ITS PRODUCTS.

246. An outline of the methods followed in determining quantitatively the main components of milk and its products is given in the following for the guidance of advanced dairy students. This work cannot be done outside of a fairly well-equipped chemical laboratory, or by persons who have not been accustomed to handling delicate chemical apparatus and glassware, analytical balances, etc., and who have not a knowledge of, at least, the elements of chemistry and chemical reactions

A.—Milk.

247. In a complete milk analysis, the specific gravity of the milk is determined, and the following milk components: water, fat, casein and albumen, milk sugar, and ash. The methods of analysis described in the following are those adopted by the Association of Official Agricultural Chemists of North America, which, with but slight modifications, are in general use in the chemical laboratories of all American experiment stations and agricultural colleges.[1]

248. a. **Specific gravity** is determined by means of a picnometer or specific-gravity bottle, since more ac-

[1] The complete methods of analysis adopted by the Association of Official Agricultural Chemists are published by the Bur. of Chemistry of the U. S. Department of Agriculture; see Bull. No. 107, pp. 117-128.

curate results will thus be reached than by using an ordinary Quevenne lactometer. A thermometer is ground into the neck of the specific-gravity bottle so as to form a stopper, and the bottle is provided with a glass-stoppered side-tube, to furnish an exit for the liquid on expanding. A specific-gravity bottle holding 100 grams of water is preferably used. The empty and scrupulously cleaned bottle is first weighed on a chemical balance. The bottle is then filled with recently-boiled distilled water of a temperature below 60° F. (15.5° C.); the thermometer is inserted, and the bottle is warmed slightly by immersing it for a moment in tepid water and left standing until the thermometer shows 60° F.; the opening of the side tube is then wiped off and closed with the stopper, and the water on the outside of the bottle and in the groove between its neck and the thermometer is wiped off with filter paper or a clean handkerchief, when the bottle is again weighed. The weight being recorded, the bottle is emptied and dried in a water oven, or if sufficient milk is at hand, the bottle is repeatedly rinsed with the milk, the specific gravity of which is to be determined. It is then filled with milk in a similar manner as in case of water; the temperature of the milk should be slightly below 60° F. and is slowly brought up to this degree after the bottle has been filled, proceeding in the same way as before with water; the weight of the bottle and milk is then taken

The weights of water and of milk contained in the specific-gravity bottle are found by subtracting the weight of the empty bottle from the second and the third weights, respectively, and the specific gravity of

the milk then found by dividing the weight of the milk by that of the water.

Example: Weight of sp. gr. bottle+water...146.9113 grams.
Weight of sp. gr. bottle empty... 46.9423 grams.

Weight of water..... 99.9690 grams.
Weight of sp. gr. bottle+milk.....149.8708 grams.
Weight of sp. gr. bottle empty... 46.9423 grams.

Weight of milk.....102.9285 grams.

Sp. gr. of milk $= \frac{102.9285}{99.969} = 1.0296$.

249. If a plain picnometer without a thermometer attached is available, the method of procedure is similar to that described, with the difference that the temperature of the water and of the milk must be brought to 60° F. before the picnometer is filled, or the picnometer filled with either liquid is placed in water in a small beaker, which is very slowly warmed to 60° F. and kept at this temperature for some time so as to allow the liquid in the picnometer to reach the temperature desired; the temperature of the water in the beaker is as ertained by means of an accurate chemical thermometer. The perforated stopper is then wiped off, the picnometer is taken out of the water, wiped and weighed. It is necessary to weigh very quickly if the room temperature is much above 60° F., as in such cases the expanding liquid will flow on to the balance pan, with a resultant loss in weight from evaporation.

The weights of specific-gravity bottle or picnometer, empty and filled with water, need only be determined a couple of times, and the averages of these weighings are used in subsequent determinations.

250. Westphal balance. Where only a small amount of milk is available, or in rapid work, the specific gravity may be taken with considerable accuracy by means of a Westphal balance. The arrangement and use of this convenient little apparatus is readily explained verbally.

For the determination of the specific gravity of *lop-pered milk,* see 263.

251. b. **Water.** The milk is weighed into a perforated copper tube filled with prepared dry asbestos. The tubes are made from perforated sheet copper, with holes about .7 mm. in diameter and about .7 mm. apart; they are 60 mm. long, 25 mm. in diameter and closed at the bottom. The asbestos is prepared from clean fibrous asbestos, which is ignited at low heat in a muffle oven, treated with a little dilute HCl (1:3) and then with distilled water till all acid is washed out; it is then torn in loose layers and dried at a low temperature in an air bath; when dry it can be easily shredded in fine strings, and is placed in a wide-mouth, glass-stoppered bottle.

About two grams of asbestos are placed in each tube, packing it rather loosely; the tube is then weighed, a small narrow beaker being inverted over it on the scale pan. 5 cc. of milk are now dropped on to the asbestos from a 5 cc. fixed pipette, the beaker again placed over the tube, and the weight of the 5 cc. of milk delivered +copper tube taken. The weight of the milk is obtained by difference. The tubes are then placed in a steam oven and heated at 100° C. until they no longer decrease in weight, which will ordinarily take about three hours. Place in a desiccator until cold, and weigh; the difference between the weight of the tube+milk and this last weight gives the water contained in the milk, which is then calculated in per cent. of the quantity of milk weighed out.

Example:

Weight of tube+beaker+milk....	29.3004 grams.
Weight of tube+beaker.....	24.1772 grams.
Milk weighed out.....	5.1232 grams.
Weight of tube+beaker+milk....	29.3004 grams.
Weight of tube+beaker+milk,dry	24.9257 grams.
Weight of water.....	4.3747 grams.

Per cent. of water in milk $= \frac{4.3747 \times 100}{5.1232} = 85.39$ per cent.

Note. The per cent. of *total solids* in milk is often given, instead of that of water; this may be readily obtained by subtracting the weight of the empty tube from that of the tube filled with milk solids, and finding the per cent. of the milk weighed out which this difference makes. In the above example, the weight of milk solids thus is 24.9257—24.1772=.7485 gram, and the per cent. of total solids in the milk=14.61 per cent.

252. **Alternate method.** Five cc. of milk are measured out on a weighed flat porcelain dish (50-60 mm. in diameter; porcelain covers will answer the purpose well if the handle be broken off or ground off level on an emery wheel); this is weighed rapidly; two or three drops of 30 per cent.-acetic acid are added, and the dish is dried in a steam oven at 100° C. until no further loss in weight occurs. After cooling in a desiccator, the weight of the milk solids is obtained, and by calculation as before, the per cent. of water or total solids in the milk.

253. c. **Fat.** The dried tubes from the water determination are placed in Caldwell extractors and connected with weighed, numbered glass flasks (capacity, 2-3 oz.); the extractors are attached to upright Liebig condensers and the tubes extracted with pure ether, free from water, alcohol or acid, until all fat is dissolved; 4-5 hours' extraction is sufficient for whole milk; in case of samples of skim milk it is well to con-

tinue the extraction for 8 hours. The ether is then recovered by distillation, and the flasks dried in a steam oven until constant weight; after cooling they are weighed and the amount of fat contained in the quantity of milk originally weighed into the tubes is thus ascertained, and the per cent. present in the milk calculated.

Example: Weight of flask+fat..... 15.8039 grams.
Weight of flask..... 15.5171 grams.

Weight of fat..... .2868 gram.
Milk weighed out..... 5.1232 grams.

Per cent. of fat in milk= $\frac{.2868\times100}{5.132}$ =5.60 per cent.

254. The Gottlieb method for the determination of fat.[1] 10 cc. of milk are measured into a glass cylinder, ¾ inch in diameter and about 14 inches long (a 100 cc. burette or a Eudiometer tube will do); 1 cc. conc. ammonia is added and mixed thoroughly with the milk; the following chemicals are next added in the order given: 10 cc. of 92 per cent. alcohol, 25 cc. of washed ether, and 25 cc. petroleum ether (boiling pt., below 80° C.), the cylinder being closed with a moistened cork stopper and the contents shaken several times after the addition of each chemical. The cylinder is then left standing for six hours or more. The clear fat solution is next pipetted off into a small weighed flask, by means of a siphon drawn to a fine point (see fig. 6, loc. cit.), which is lowered into the fat solution to within ½ cm. of the turbid bottom layer. After evaporating the ether solution in a hood, the flasks are dried in a steam oven

[1] Landw. Vers. Sta., 40 (1892), pp. 1-27. The method is also spoken of as the Roese-Gottlieb method. The Mojonnier tester (108) is based on this method and is largely used in milk-condensing factories for determining solids and butter fat in condensed milk and other dairy products.

for two to three hours, and weighed. This method is applicable to new milk, skim milk, butter milk, whey, cream, cheese, condensed milk and milk powder, but has been found of special value for determining fat in skim milk, butter milk, cheese, and condensed milk. In the case of products high in fat, a second treatment with 10 cc. each of ether and petroleum is advisable in order to recover the last traces of fat.

255. d. Casein and albumen. The sum of these components is generally determined by the Kjeldahl method.[1] 5 cc. of milk are measured carefully into a 800 cc. Jena flask, 20 cc. of concentrated sulfuric acid (C. P.; sp. gr., 1.84) are added, and .7 gram of mercuric oxid (or its equivalent in metallic mercury); the mixture is then heated over direct flame until it is straw-colored or perfectly white; a few crystals of potassium permanganate are now added till the color of the liquid remains green. All the nitrogen in the milk has then been converted into the form of ammonium sulfate. After cooling, 200 cc. of ammonia-free distilled water are added, 20 cc. of a solution of potassium sulfid (containing 40 grams sulfid per liter), and a fraction of a gram of powdered zinc. A quantity of semi-normal HCl-solution, more than sufficient to neutralize the ammonia obtained in the oxidation of the nitrogen in the milk, is now carefully measured out from a delicate burette (divided into $\frac{1}{20}$ cc.) into a receiving flask and the flask connected with a distillation apparatus. At the other end, the Jena flask containing

[1] Fresenius' Zeitschrift, 22, p. 366; U. S. Dept. Agr., Bur. of Chem. Bull. 107, p. 5.

the watery solution of ammonia sulfate is connected, after adding 50 cc. of a concentrated soda solution (1 pound "pure potash" dissolved in 500 cc. of distilled water and allowed to settle); the contents of the Jena flasks are now mixed and heated to boiling, and the distillation is continued for forty minutes to an hour, until all ammonia has been distilled over.

The excess of acid in the Erlenmeyer receiving-flask is then accurately titrated back by means of a tenth-normal standard ammonia-solution, using a cochineal-solution[1] as an indicator. From the amount of acid used, the per cent. of nitrogen is obtained; and from it, the per cent. of casein and albumen in the milk by multiplying by 6.25.[2] The amount of nitrogen contained in the chemicals used is determined by blank experiments and deducted from the nitrogen obtained as described.

Example: The weight of 5 cc. of milk (as obtained in determining the water in the milk) was 5.1465 grams. 5 cc. of standard HCl are added to the receiver, and 1.55 cc. of $\frac{10}{N}$ alkali solution are used in titrating back the excess of acid. 1.55 cc. of $\frac{N}{10}$ alkali $= \frac{1.55}{5} = .31$ cc. $\frac{N}{2}$ acid solution; the ammonia distilled over therefore neutralized 5.00—.31=4.69 cc. acid. By blank trials it was found that the reagents used furnished an equivalent of .02 cc. acid in the distillate; this quantity subtracted from the acid-equivalent of the nitrogen of the milk leaves 4.67 cc. 1 cc. semi-normal HCl solution corresponds to 7 milligrams or .007 gram of nitrogen; 4.67 cc. $\frac{N}{2}$ HCl therefore represents .03269 gram of nitrogen. This quantity of nitrogen was obtained from the 5.1465 grams of milk measured out; the milk therefore contains $\frac{.03269 \times 100}{5.1465} = .635$ per cent. of nitrogen, and $.635 \times 6.25 = 3.97$ per cent. of casein and albumen.

[1] Sutton, Volumetric Analysis, 4th edition, p. 31.

[2] The factor 6.30 or 6.37 is more correct for the albuminoids of milk, but has not yet been generally adopted (p. 15, foot note).

256. *Casein and albumen* may be determined separately by Van Slyke's method;[1] 10 grams of milk are weighed out and diluted with about 90 cc. of water at 40°-42° C. 1.5 cc. of a 10 per cent. acetic-acid solution are then added; the mixture is well stirred with a glass rod and the precipitate allowed to settle for 3 to 5 minutes. The whey is decanted through a filter and the precipitate washed two or three times with cold water. The nitrogen is determined in the filter paper and its contents by the Kjeldahl method; blank determinations with the regular quantities of chemicals and the filter paper used are made, and the nitrogen found therein deducted. The per cent. of nitrogen obtained multiplied by 6.25 gives the per cent. of casein in the milk.

257. *Albumen* is determined in the filtrate from the casein-precipitate; the filtrate is placed on a water bath and heated to boiling for a period of from ten to fifteen minutes. The washed precipitate is then treated by the Kjeldahl method for the determination of nitrogen; the amount of nitrogen multiplied by 6.25 gives the amount of albumen in the milk. The difference between the total nitrogenous components found by the Kjeldahl method, and the sum of the casein and the albumen, as given above, is due to the presence in milk of a third class of nitrogen compounds (18).[2]

257a. The protein of milk may also be obtained by calculation from the total solids of the milk by the use of the following formula worked out by Mr. Geo. A.

[1] Bulletin 107, p. 117, Bur. of Chem., U. S. Dept. of Agriculture.

[2] Volumetric determinations of casein in milk have been proposed by Van Slyke and Bosworth (Geneva, N. Y.) expt. station, tech. bull. 10) and by Hart (Wis. expt. station, research bull. 11).

Olson[1]: $P=T-\frac{T}{1.26}$ The results obtained by this formula are quite satisfactory. If we assume that .8 of the milk protein is casein, this component can also be obtained from the solids of the milk by a simple calculation by the use of the preceding formula.

258. Hart's test for casein in milk. The following test for casein in milk has been published by the Wisconsin experiment station.[2]

Two cc. of chloroform, 20 cc. of a .25 per cent. solution of acetic acid, and 5 cc. of milk (both these latter of a temperature of about 70° F.) are measured into small tubes of special construction holding about 35 cc., the lower ends of which are narrow and graduated to .1 cc. The mixture is shaken for 10 to 20 seconds and the tubes then whirled 7½ or 8 minutes in a centrifuge of 15 inches diameter, making 2000 revolutions per minute. (The use of a metronome is recommended to facilitate the control of the speed.) After whirling, the tubes are taken out of the centrifuge and allowed to stand for 10 minutes, and the percentage of casein read off directly from the scale on the lower end of the tubes, each division of which represents .2 per cent. of casein when 5 cc. of milk are measured out. The test calls for considerable nicety of manipulation, but appears to give reliable results when the directions given are strictly followed.[3]

259. e. Milk sugar is generally determined by difference, the sum of fat, casein and albumen (total N×6.25),

[1] Journ. Ind. and Eng. Chemistry, I, 1909, p. 253.

[2] Report 24, p. 117: "A simple method for the estimation of casein in cow's milk."

[3] See also Circ. 10, Wis. expt. sta., Operating the casein test at cheese factories.

and ash, being subtracted from the total solids. It may be determined directly by means of a polariscope, or gravimetrically by Fehling's solution; only the former method, as worked out by Wiley,[1] will be given here.

The specific gravity of the milk is accurately determined, and the following quantities of milk are measured out by means of a 100 cc. pipette graduated to .2 cc. (or a 64 cc. pipette made especially for this purpose, with marks on the stem between 63.7 and 64.3 cc.), according to the specific gravities given: 1.026, 64.3 cc.; 1.028, 64.15 cc.; 1.030, 64.0 cc.; 1.032, 63.9 cc.; 1.034, 63.8 cc.; 1.036, 63.7 cc. These quantities refer to the Schmidt-Haensch half-shadow polariscopes, standardized for a normal weight of 26.048 grams of sugar. The milk is measured into a small flask graduated at 100 cc. and 102.6 cc.; 30 cc. of mercuric-iodid solution (prepared from 33.2 grams potassium iodid, 13.5 grams mercuric chlorid, 20 cc. glacial acetic acid and 640 cc. water) are added; the flask is filled to 102.6 cc. mark with distilled water, the contents mixed, filtered through a dry filter, and when the filtrate is perfectly clear, the solution is polarized in a 200 millimeter tube. The reading of the scale divided by 2, shows the per cent. of lactose (milk sugar) in the milk. Take five readings of two different portions of the filtrate, and average the results.

260. f. Ash. About 20 cc. of milk are measured into a flat-bottom porcelain dish and weighed; about one-half of a cc. of 30 per cent.-acetic acid is added, and the milk first dried on water bath and then ignited in a

[1] Agricultural Analysis, III, p. 275; Am. Chem. Jour., 6, p. 289 et seq.

muffle oven at a low red heat. Direct heat should not be applied in determining the ash in milk, since alkali chlorids are likely to be lost at the temperature to which milk solids have to be heated to ignite all organic carbon.

Example:

Weight of porcelain dish+milk....	49.0907 grams.
Weight of porcelain dish.....	28.3538 grams.
Weight of milk.....	20.7369 grams.
Weight of dish+milk, after ignition	28.5037 grams
Weight of dish.....	28.3538 grams.
Weight of milk ash.....	.1499 gram

Per cent. of ash $= \frac{.1499 \times 100}{20.7369} = .72$ per cent.

The residue from the determination of solids by the Alternate Method given (252) may also be used for the ash determination.

B.—Cream, Skim milk, Butter milk, Whey, Condensed milk.

262. The analysis of these products is conducted in the same manner as in case of whole milk, and the same constituents are determined, when a complete analysis is wanted. Skim milk, butter milk, and whey contain relatively small quantities of solids, and especially of fat, and it is, therefore, well to weigh out a larger quantity than in case of whole milk; if possible, toward 10 grams. The acidity of sour milk and butter milk must be neutralized with sodium carbonate previous to the drying and extraction, as lactic acid is soluble in ether and would thus tend to increase the ether-extract (fat), if not combined with an alkali previous to the extraction.

263. **Specific gravity of butter-milk.** The specific gravity of butter milk (as well as of sour or loppered milk) is determined by Weibull's method; a known volume of the milk is mixed with a certain amount (say 10 per cent.) of ammonia of a definite specific gravity, and the specific gravity of the liquid determined after thorough mixing and subsequent standing for an hour. If A designate the volume of butter milk taken, B that of ammonia, and C that of the mixture; and if furthermore S designate the specific gravity of the butter milk, s_1 that of the ammonia, and s_2 that of the mixture, we have

$$\frac{Cs_2 - Bs_1}{A}$$

Klein[1] has modified this method by weighing the liquids, thus securing greater accuracy; 22 to 24 per cent.-ammonia is used, one-tenth as much being taken as the amount of milk weighed out. The results come uniformly .0005 too high, and this correction should always be made. The following formula will give the specific gravity of the milk, which in case of careful work will be accurate to one-half lactometer degree; if the letters given above designate weights (instead of volumes as before) and specific gravities of the liquids, respectively, we have

$$S = \frac{A}{\frac{C}{s_2} - \frac{B}{s_1}}$$

264. **Condensed milk.** The same methods are, in general, followed in the analysis of condensed milk as with whole milk. Condensed milk is preferably diluted with five times its weight of water prior to the analysis, both because such a solution can be more easily handled than the undiluted thick condensed milk, and the errors of analysis are thereby reduced, and because the fat is not readily extracted except when the milk has been

[1] Milchzeitung, 1896, p. 656; see also De Koningh, Analyst, 1899, p. 142.

diluted.[1] The same constituents are determined as in case of whole milk, viz., solids, fat, casein and albumen, ash, milk sugar, and cane sugar (if any has been added to the milk). The cane sugar is determined by the difference between the solids not fat and the sum of the casein, albumen, milk sugar and ash; if the student has a knowledge of the manipulation of the polariscope and has had experience in gravimetric sugar analysis, the milk sugar is determined gravimetrically, and the cane sugar by the difference between the polariscope reading after inversion and the milk sugar present.

The *specific gravity of condensed milk* may be determined by a method similar to that of McGill.[2] 50 gr. of the thoroughly mixed sample are weighed into a tared beaker and washed with warm water into a 250 cc flask, cooled to 60°, filled to the mark and carefully mixed. The specific gravity of this solution (a) is then taken and the original density is calculated by means of the following formula:

$$\text{Sp. gr. of condensed milk} = \frac{1}{6-5a}$$

Concentration. The extent of concentration of condensed milk may be determined approximately by the formula devised by McGill (loc. cit.):

$$\text{Concentration (c)} = \frac{a\,s}{a_1\,s_1}$$

where a and s designate the solids not fat and specific gravity, respectively, of the condensed milk, and a_1 and s_1 the corresponding data for the milk used. If $s_1 =$

[1] A second extraction following leaching and subsequent drying of the tubes is necessary to extract all the fat in condensed milk; see Bull. 104, Bur. of Chem., U. S. Dept. of Agr., p. 102 and 154.

[2] Bulletin 54, Laboratory Inland Rev. Dept., Ottawa, Canada.

1.030 and a_1=9 per cent., then $c=\frac{as}{9.27}$ gives the concentration.

C.—Butter.

265. Sampling. A four- to eight-ounce sample of butter is melted in a tightly-closed pint fruit jar, shaken vigorously and cooled until the butter is hardened, the jar being shaken vigorously at short intervals during the cooling so as to keep the water of the butter evenly distributed in the mass (102).

266. a. Determination of water. Small pieces of butter (about 2 grams in all) are taken from the sample by means of a steel spatula and placed in glass tubes seven-eighths of an inch in diameter and two and a half inches long, closed at the bottom by a layer of stringy asbestos, and filled two-thirds full of asbestos prepared as for milk analysis (252). The tubes are dried at 100° C. in a steam oven, until no further loss in weight takes place, and are then cooled and weighed. The loss in weight shows the per cent. of water present.

267. b. Fat. The tubes are placed in Caldwell extractors and extracted for four hours with anhydrous ether; the ether is then distilled off, and the flasks dried in the steam bath and weighed, the increase in weight giving the fat in the sample of butter weighed out.

268. c. Casein. 10 grams of butter are weighed into a small beaker provided with a lip, and treated twice with about 50 cc. of gasoline each time; the solution is filtered off, and the residue transferred to a filter and dried; its nitrogen content is then determined by the Kjeldahl method (255). The nitrogen in the filter and

the chemicals used is determined by blank trials and deducted. The nitrogen multiplied by 6.25 gives the casein in the butter.

269. d. **Ash.** (1) 10 grams of butter are weighed into a porcelain dish and treated twice with gasoline, as in the preceding determination; the solution is filtered through an ash-free (quantitative) filter, and the filter when dry is transferred to the dish. The dish is heated in an air-bath for half an hour and then placed in a muffle oven, where the contents are burnt to a light grayish ash; the dish is now cooled in a desiccator and weighed. The difference between this weight and that of the empty dish gives the amount of ash in the butter weighed out.

270. (2) About two grams of butter are weighed into a small porcelain dish, half filled with stringy asbestos; the dish is dried for half an hour in the water oven, and the fat then ignited with a match, the asbestos fibre serving as a wick. When the flame has gone out, the dish is placed in a muffle oven, and the residue carefully burnt to a grayish ash. After cooling, the dish is weighed, and the per cent. of ash in the butter calculated as under method 1.

271. **Complete analysis of butter in the same sample.** About 2 grams of the butter are weighed into a porcelain gooch half filled with stringy asbestos, and dried in a steam oven at 100° C. to constant weight, cooled and weighed. The difference gives *water* in the sample. The gooch is then treated repeatedly with small portions of gasoline, suction being applied, and again dried in the water oven, cooled, and weighed; the

fat in the sample is obtained from the difference between this and the preceding weight. The gooch is then carefully heated at a low red heat until a light grayish ash is obtained; this operation is preferably done in a muffle oven to avoid a loss of alkali chlorids. The loss in weight gives the *casein* in the sample weighed out, and the increase in the weight of the gooch over that of the empty gooch with asbestos, gives the *ash* (mainly salt) of the butter. The *salt* in the ash may be dissolved out by hot water, and the chlorin content of the solution determined by means of a standard silver-nitrate solution, using potassium chromate as an indicator (278).

272. Creamery methods of estimating water in butter. A number of different methods have been proposed of late years for the rapid estimation of water in butter, the object sought being to enable a buttermaker to ascertain the water content of his butter without much trouble or delay, and by using such simple apparatus as he is likely to have in the creamery or can easily procure at a low price. The subject of controlling the per cent. of water in butter has become more important than was earlier the case, through the passage of the pure-food law, and the promulgation of government food standards in

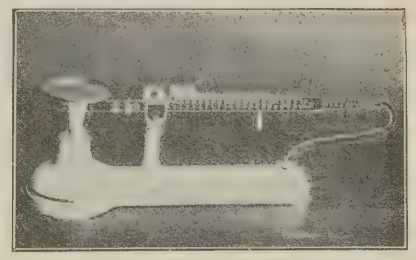

FIG. 58a. Balance for weighing butter for testing.

1906 (305); these measures have rendered the question of guarding against an excessive water content in the butter one of the greatest importance to all butter-makers.

Most of the methods suggested for this purpose are essentially the common method of chemical analysis modified to meet the demands of every-day factory conditions. References to descriptions of the different methods proposed are given below, and a few that are now used in factories and outside of chemical laboratories, are described in detail.

FIG. 58b. Scale for weighing butter for testing.

In all these rapid methods of determining the water content in butter, the sample of butter must be prepared so as to accurately represent the lot of butter sampled (see 102), and must be carefully weighed on a delicate scale (see figures 58a and b). The directions, in so far as they are given in detail in the following, therefore, presuppose that a carefully prepared, fair sample has been obtained in all cases.

273. Among the methods proposed for the rapid determination of the per cent. of water in butter that are adapted for use in creameries may be mentioned: Richmond's method,[1] Carroll's tester,[2] Geldard's but-

[1] Dairy Chemistry, p. 252.

[2] Dept. of Agr., Ottawa, Dairy Com'r Branch, bull. 6, pp. 10-11.

ter tester,[1] the Irish "common sense butter and cheese test," Dean's,[2] Gray's,[3] Patrick's,[4] the Wisconsin high-pressure oven method,[5] the Benkendorf moisture test,[6] the Ames method,[7] the Mitchell-Walker test,[8] and the Cornell moisture test.[9]

274. Patrick's method. Ten grams of butter are accurately weighed into a 300 cc. aluminum beaker (about 3 inches tall and 2 inches in diameter); this is held by means of a hand clamp over the flame of the alcohol lamp or a gas burner (see fig. 59) and very carefully heated until all the water is expelled. The beaker is then cooled by sinking it to the rim in water of 50° to 60°, wiped dry, and the loss in weight calculated as water. If ten grams of butter weighed 8.45 grams after heating, the loss in weight of 1.55 grams represents 15.5 per cent. of the weight of the sample, and the butter there-

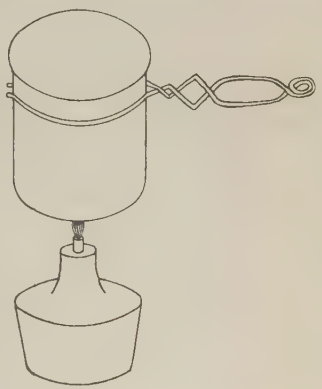

FIG. 59. Aluminum beaker and alcohol lamp used in the Patrick test.

[1] Dept. of Agr., Ottawa, Dairy Com'r Branch, bull. 14, pp. 6–8.
[2] Ontario Agr. College, rept. 1906, p. 120.
[3] Circ. 100, Bur. An. Ind., U. S. Dept. of Agr.
[4] Journal Am. Chem. Soc., 28, 1906, p. 1611.
[5] Bull. 154, Wis. exp. sta.
[6] Bull. 220, Wis. exp. sta.
[7] Bull. 97, Iowa exp. sta.
[8] Bull. 167, Dairy Branch, Ont. Dept. of Agr.
[9] Bull. 281, Cornell exp. sta.

fore contained 15.5 per cent. of water.[2] The results obtained by this method seldom vary more than .2 per cent. from those of chemical analysis, and often less than .1 per cent. when proper care in sampling and weighing has been taken.

A few points need special attention in using this method: *First,* care must be taken not to heat the beaker too fast so that spattering occurs; there is not so much danger from this source when an alcohol lamp is used as with a gas burner, which easily raises the temperature too high, causing a fine spray of material to be thrown about, and thus giving too high results for water content. *Second,* it is important to discontinue the heating at the exact point when all the water has been driven off and before burning of the non-fatty solids (casein, milk sugar, and organic acids) occurs, as indicated by a slight darkening in color. It is not necessary to cool the beakers in water, but they can be left to cool in the air. The determination of water in butter by this method can be finished in ten minutes or less by an experienced operator.

The *Irish* test is similar to the method described in the preceding, differing from the same mainly in the shape of the aluminum dishes used. Modifications of this test have also been worked out by the Iowa and Cornell experiment stations, which are designed to prevent losses by spattering when the dish is heated. In the *Ames method* the aluminum dish containing the

[2] A convenient table showing per cents of moisture in butter direct when 9 to 10.15 grams are weighed out, has been published by the Copenhagen experiment station (62nd report; see N. Y. Produce Rev., 1908, p. 530).

sample is heated with a paraffine bath, while in the *Cornell test* a thin sheet of asbestos is placed between the flame and the dish holding the samples.

275. Dean's method. Three cc. of a melted sample of butter are placed in an ordinary "patty-pan" tin dish (about 2½ inches in diameter and ½ inch deep) and accurately weighed; the dish is then placed in a steam oven provided with a pop safety valve, a steam pressure gauge, and a thermometer. The oven used by Professor Dean of Guelph (Ont.) Dairy School, the originator of this method, was 6x8 inches. It was made of galvanized iron by a local tin-smith at a cost of about $5.00, exclusive of safety valve and steam gauge, and was made to withstand a pressure of about 10 pounds. After five or six hours' drying in the oven, the samples of butter are ready to be weighed, and the loss gives the amount of water present therein. The average results obtained by this method with nine samples of butter came within .13 per cent. of those found by chemical analyses.

The same method is recommended by the author for determining the per cent. of water in curd or cheese.

276. The Wisconsin high-pressure oven method (see fig. 60). Either 10 or 50 grams of butter are weighed in a flat-bottomed tin or aluminum dish. This is placed in an oven heated by high pressure steam to a temperature of 240° to 280° F. The length of time required to expel all the water from the butter will depend on the temperature of the oven and the diameter of the dish in which the butter is heated. If the dish

is large enough to permit the butter to spread into a very thin layer and the temperature of the oven reaches 260° F., the water will be completely expelled in half an hour. Ovens of this construction have now been placed on the market by manufacturers of dairy supplies. A steam pressure of 60 lbs. and a temperature of 280° F. may be obtained in such an oven; by employing the boiler pressure ordinarily used in a creamery, temperatures of 240° to 260° may be easily obtained. The temperature thus reached is sufficient to dry the butter completely within an hour, provided pans large enough to spread the butter in a thin layer are used.

If 10 grams of butter are used in making tests, a more delicate scale is necessary than when 50 grams are taken. There are other advantages in using as large a quantity as 50 grams of butter for making tests of water. *First,* a sample can be weighed out directly from a package. *Second,* ordinary tin basins at least 5 inches in diameter can be used for drying the butter. *Third,* scales with a graduated side beam and sensitive to .1 gram instead of those with smaller loose weights can be used for weighing the butter. (See figs. 58d and 58e.)

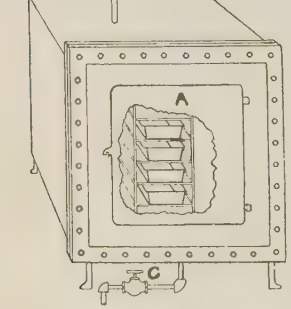

Fig. 60. The Wisconsin high-pressure oven.

277. The Benkendorf moisture tester consists of a small cast-iron oven ($3\frac{1}{2}$x$3\frac{1}{2}$ inches, 1 inch deep) which is heated by an alcohol or gas lamp. A thin piece of asbestos is placed on the bottom of the oven. This aids in distributing the heat so that the butter which is weighed into a shallow, flat-bottom aluminum dish, about three inches in diameter, is heated from above as well as from below. 10 grams of butter are commonly used in this test and the moisture evaporates in about five to ten minutes.

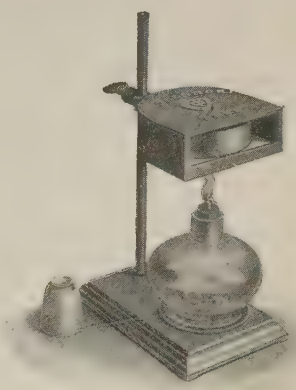

Fig. 61. The Benkendorf tester.

278. Creamery methods of estimating salt in butter. I. The ordinary volumetric method used in chemical laboratories for determining the salt content of butter has been adapted for work in the creamery by Prof. Sammis.[1] 5.1 grams of chemically pure nitrate crystals are dissolved in 250 cc. of water. Each cc. of this solution will represent 1 per ct. of salt when 17.6 cc. of the liquid are measured which is obtained by shaking 10 grams of butter with 250 cc. of clean, warm water. The silver nitrate solution is added from a 25 or 50 cc. burette divided into tenths of a cubic centimeter. One or two drops of the usual indicator employed (1 oz. potassium chromate dissolved in 100 cc. of water) are added prior to the titration.

II. The use of silver nitrate tablets for making standard solutions for volumetric determinations of salt in butter was

[1] Circ. 14, Wisconsin expt. station.

proposed by Prof. A. Vivian and C. L. Fitch in 1901.[1] The tablets have not been on the market during late years.

278a. Shaw's test for fat and salt in butter. R. H. Shaw has devised a method for determining the percentages of fat and salt in the same sample of butter which has considerable merit. For description of this method see Circ. 202, Bur. of Animal Ind., U. S. Dept. of Agriculture.

Detection of Artificial Butter.

279. Determination of the specific gravity of the filtered butter fat serves as a good preliminary test. A number of practical methods for the detection of artificial butter have been proposed, but they are either worthless for the examination of samples containing a considerable proportion of natural butter, or give satisfactory results only in the hands of experts. The Reichert-Meissl method given in detail below is the standard method the world over, and the results obtained by it are accepted in the courts.

280. Filtering the butter fat. The butter to be examined is placed in a small narrow beaker and kept at 60° C. for about two hours. The clear supernatant fat is then filtered through absorbent cotton into a 200 cc. Erlenmeyer flask, taking care that none of the milky lower portion of the contents of the beaker be poured on the filter. In sampling the butter fat, it is poured back and forth repeatedly from a small warm beaker into the flask, and the quantity wanted is then drawn off with a warm pipette.

[1] Wis. experiment station, report 17, pp. 98-101; Hoard's Dairyman, February 15, 1901, "Uniform Salting of Butter."

281. Specific gravity. This is generally determined at 100° C. The method of procedure is similar to that described under milk (248). The picnometer (capacity about 25 cc.) is filled with dry filtered butter fat, free from air bubbles; the fat is heated for 30 minutes in a beaker, the water in which is kept boiling. On cooling, the weight of picnometer and fat is obtained, and by calculation as usual, the specific gravity of the fat.

The specific gravity of pure natural butter fat at 100° C. ranges between .8650 and .8685, while artificial butter fat (i. e., fat from other sources than cow's milk) has a specific gravity at 100° C. of below .8610, and generally about .85.

282. Reichert-Meissl method (*Volatile Acids.*) 5.75 cc. of fat are measured into a strong 250 cc. weighed saponification flask, by means of a pipette marked to deliver this amount, and the flask when cool is weighed again. 20 cc. of a glycerol-soda solution (20 cc. of soda solution (1 : 1) to 180 cc. of pure glycerol), are then added to the flask and the flask is heated over a naked flame or hot asbestos plate until complete saponification has taken place, as shown by the mixture becoming perfectly clear. If foaming occur, the flask is shaken gently.

135 cc. of recently-boiled distilled water are now added, drop by drop, at first, to prevent foaming, and when the solution is clear, cooled to about 70° C.; 5 cc. of dilute sulfuric acid (200 cc. conc. H_2SO_4 per liter) are added to the soap solution to decompose the soap into free fatty acids and glycerol. A few pieces of pumice stone (prepared by throwing the pieces at white heat

into distilled water and keeping them under water until used) are added, the flask connected with a glass condenser, heated slowly till boiling begins, and the contents then distilled at such a rate as will bring 110 cc. of the distillate over in as nearly thirty minutes as possible.

The distillate is mixed thoroughly and filtered through a dry filter; 100 cc. of the filtrate are poured into a 250 cc. beaker and titrated with a deci-normal barium-hydrate solution, half a cubic centimeter of phenolphtalein solution being used as an indicator. A blank test is made in the same manner as described, and the amount of alkali solution used deducted from the results obtained with the samples analyzed. The number of cubic centimeters of barium-hydrate solution used is increased by one-tenth, and the so-called *Reichert* or *Reichert-Meissl number* thus obtained.

The Reichert number for pure butter fat will ordinarily come above 24 cc. and may go over 30 cc; butter fat from stripper cows will have a low Reichert number. Pure oleomargarine will have a Reichert number of 1 to 2 cc.; and mixtures of artificial and natural butter will give intermediate numbers.

Tests for the Detection of Oleomargarine or Renovated Butter.

283. **The boiling test.**[1] A piece of butter of the size of a small chestnut is melted in an ordinary tablespoon

[1] Patrick, Household tests for the detection of oleomargarine and renovated butter, Farmer's Bulletin, No. 131. For detection and examination of renovated or "process" butter, see also Cochran, *Journ Frankl. Inst.*, 1899, p. 94; *Analyst*, 1899, p. 88.

(or a small tin dish) at a low heat, stirring with a splinter of wood. The heat is increased until as brisk a boil as possible, and after boiling has begun, the melted mass is stirred thoroughly two or three times, always shortly before boiling ceases. Oleomargarine and renovated butter will boil noisily, sputtering like a mixture of grease and water when boiled, and will produce but little or no foam. Renovated butter produces usually a very small amount of foam, while genuine butter boils with less noise and produces an abundance of foam.

284. **The Waterhouse test** for distinguishing oleomargarine and renovated butter.[1] Half fill a 100 cc. beaker with sweet skim milk (or distilled water), heat nearly to boiling and add 5 to 10 grams of butter or oleomargarine. Stir with a small wooden stick of about the size of a match until the fat is melted; the beaker is then placed in ice water, and the milk (or water) stirred until the temperature falls sufficiently for the fat to congeal. If oleomargarine, the fat can now be easily collected into one lump by means of the stick, while if genuine or renovated butter, the fat will granulate and can not be so collected.[2]

D.—Cheese.

For method of sampling, see par. 104.

285. a. **Water.** Five grams of cheese cut into very thin slices are weighed into a small porcelain dish filled about one-third full with freshly-ignited stringy asbes-

[1] Farmers' Bulletin No. 131, p. 7.

[2] For tests for artificial coloring matter in oleomargarine, see Circ. 629, Com. of Internal Rev., Treasury Dept.

tos; the dish is placed in a water oven and heated for ten hours. The loss in weight is taken to represent water.

In cheese factories the Wisconsin high-pressure oven (276) is now used for making moisture tests of cheese. A 10-gram sample requires about five hours' heating to expell all the moisture in the cheese. The rapid methods for moisture testing of butter do not give satisfactory results with cheese.[1]

286. b. Fat. About 5 grams of cheese are ground finely in a small porcelain mortar with about twice its weight of anhydrous copper sulfate, until the mixture is of a uniform light blue color and the cheese evenly distributed throughout the mass. The mixture is transferred to a glass tube of the kind used in butter analysis (263), only a larger size; a little copper sulfate is placed at the bottom of the tube, then the mixture containing the cheese, and on top of it a little extracted absorbent cotton or ignited stringy asbestos; the tube is placed in an extraction apparatus and extracted with anhydrous ether for fifteen hours. The ether is then distilled off, the flasks dried in a water oven at 100° C. to constant weight, cooled and weighed. The method is apt to give too low results and, therefore, not to be preferred to the Babcock test for cheese (105).

287. c. Casein (total nitrogen$\times$6.25). About 2 grams of cheese are weighed out on a watch glass and transferred to a Jena nitrogen flask, and the nitrogen in the sample determined according to the Kjeldahl method

[1] See also Dean's method for determining water in butter, curd and cheese, 276, and the Walker casein test, N. Y. Produce Rey. 1913, p. 1154.

(253); the percentage of nitrogen multiplied by 6.25 gives the total nitrogenous components of the cheese.

288. d. **Ash.** The residue from the water determination is taken for the ash; it is preferably set fire to, in the same manner as explained under determination of ash in butter (270), before it is placed in the muffle oven and incinerated. The increase in the weight above that of the empty dish+asbestos, gives the amount of ash in the sample weighed out.

289. e. **Other constituents.** The sum of the percentages of water, fat, casein and ash, subtracted from 100, will give the per cent. of other constituents, organic acids, milk sugar, etc., in the cheese.

Detection of Oleomargarine Cheese ("Filled" Cheese.)

290. About 25 grams of finely-divided cheese are extracted with ether in a Caldwell extractor or a paper extraction cartridge; the ether is distilled off, and the fat dried in the water oven until there is no further loss in weight. 5.75 cc. of the clear fat are then measured into a 250 cc. saponification flask and treated according to the Reichert-Meissl method, as already explained under *Detection of Artificial Butter* (282).[1]

Tests for Adulteration of Milk and Cream.

291. Use of the refractometer. The immersion refractometer furnishes a delicate apparatus for the detection of watered milk.[2] 100 cc. of milk and 2 cc. of

[1] See Arb. Kais. Ges.-Amt., 14, 506-598.

[2] Leach, Food Analysis, 2nd ed., p. 168. See also Jr. Ind. and Eng. Chem., 1911, p. 44 and p. 573.

25% acetic acid are heated for twenty minutes at 70° C. This is then placed on ice for ten minutes and filtered. The refractometer reading of the clear filtrate is then taken at 20° C. If this reading is above 40 the milk is not watered, while figures below 40 show adulteration by watering.

291a. **The nitric acid test** may prove useful as corroborative evidence that a sample of milk has been watered (126). Normal fresh milk does not contain nitrates, while common well-water, particularly on farms where precautions to guard against contamination of the water supply have not been taken, in general contains appreciable amounts of nitrates, nitrites and ammonia compounds, and watered milk will, therefore, in such cases also contain nitrates.[1] The method for detection of small amounts of nitrates in milk, as given by Richmond[2] is as follows: Place a small quantity of diphenylamin at the bottom of a porcelain dish, and add to it about 1 cc. of pure H_2SO_4 (conc.); allow a few drops of the milk serum (obtained by adding a little acetic acid to the milk and warming) to flow down the sides of the dish and over the surface of the acid. If a blue color develops in the course of ten minutes, though it may be faint, it shows the presence of nitrates; after ten minutes a reddish-brown color is always developed from the action of the acid on the serum. There should be no difficulty in detecting an addition of 10 per cent. of water to the milk by this test, if the water added contained 5 parts of nitric acid, or more, per 100,000.

[1] Uffelmann, Deutsche Vierteljahresschr. f. öff. Ges.-pfl., 15, p. 663
[2] The Analyst, 1893, p. 272.

The following test for nitric acid is proposed by McKay and Bouska: About 5 cc. of milk is placed in a test tube. Some Kaniss' reagent (about 1 part formaldehyd in 500 cc. C. P. H_2SO_4) is poured down the side of the tube so it will form a layer under the milk. If nitrates or nitrites are present, a violet ring will form at the place of contact. This is Hehner's test for formaldehyd reversed, see (304).

292. Besides by the methods given in the preceding (pp. 121-127), watering or skimming of milk may be detected by determining the specific gravity of *a*, the skim milk, *b*, the milk serum, and *c*, the whey.

a. **Specific gravity of skim milk.** The milk is set in a flat porcelain or glass dish for 12 to 24 hours in a cold room; the layer of cream formed is then skimmed off, and the sp. gr. of the skim milk determined at 60° F. Skim milk has a sp. gr. of .002 to .0035 (2 to 3.5 lactometer degrees) above that of the corresponding whole milk; a smaller difference than this indicates that the milk was skimmed. If both skimming and watering had been practiced, the difference given above might be obtained, but the analysis of the milk would in such case easily disclose the adulteration.

b. **Specific gravity of the milk serum.** To 100 cc. milk 2 cc. of 20 per cent.-acetic acid are added, and the mixture heated in a covered beaker or closed flask for 5-10 min. on a water-bath at 55-65° C. After cooling, the milk serum is filtered off and its sp. gr. determined at 60° F. In case of pure milks, the sp. gr. of the milk serum (at 60°) will come above 1.0270. Serum from normal milk contains 6.3 to 7.5 per cent. solids and .22 to .28 per cent. fat; by the addition of 10 per cent. of water, the solids in the serum are lowered .3 to .5 per cent., and the sp. gr., .0005.[1]

c. **Specific gravity of whey.** 500 cc. of milk are warmed in water of 40-50° C. until its temperature is 35° C.; one-half cc. of rennet extract (12-15 drops) is added, and the milk stirred

[1] König, Menschl. Nahrungsmittel, II, p. 276.

thoroughly. After allowing the curd to solidify for 10 minutes, it is cut and the whey filtered off through several layers of cheese cloth. The whey must be clear; it is cooled to 60° F. and its sp. gr. determined. The sp. gr. of whey from normal milk obtained in the manner given will range between 1.027 and 1.031. A sp. gr. of 1.026 or below indicates watering. An addition of 4 per cent. of water lowers the sp. gr. of the whey about 1 lactometer degree.[2]

293. Detection of coloring matter. Milk which has been watered or skimmed, or both, is sometimes further adulterated by unscrupulous milk dealers by an addition of a small quantity of cheese color; this will mix thoroughly with the milk, and, if added judiciously, will impart a rich cream color to it. The presence of foreign coloring matter in milk is easily shown by shaking 10 cc. of the milk with an equal quantity of ether; on standing, a clear ether solution will rise to the surface; if artificial coloring matter has been added to the milk, the solution will be yellow colored, the intensity of the color indicating the quantity added; natural fresh milk will give a colorless ether solution.

A method gived by Wallace[1] is claimed to detect one part of coloring matter in 100,000 of milk.

Inorganic coloring matter like chromates and bi-chromates have, although fortunately rarely, been used to impart a rich color to adulterated milk or poor cream. Chromates may be detected by the reddish yellow color produced when a little 2 per cent.-silver nitrate solution is added to a few cubic centimeters of the milk.

294. Detection of pasteurized milk or cream. Prof. Storch, of Copenhagen, Denmark,[2] in 1898, published a simple method for ascertaining whether milk, cream,

[2] Siats, Unters. landw. wicht. Stoffe, p. 88.
[1] N. J. Dairy Commissioner, report 1896, p. 36.
[2] 40th report, Copenhagen experiment station.

or other dairy products have been heated to at least 176° F. (80° C.). The test is made as follows: A teaspoonful of the milk is poured into a test tube, and 1 drop of a weak solution of peroxid of hydrogen (2 per cent.) and 2 drops of a paraphenylenediamin-solution (2 per cent.) are added. The mixture is then shaken; if a dark violet color appears at once, the milk has not been heated, or at any rate not beyond 176° F. If a sample of butter is to be examined, 25 grams are placed in a small beaker and melted by being placed in water of 60° C. The clear butter fat is poured off, and the remaining liquid is diluted with an equal volume of water. The mixture thus obtained is examined as in case of milk.

Guaiacum tincture has also been recommended for the detection of pasteurized cream or milk; this solution is easily obtained, keeps well, and is convenient to use (McKay).

295. Boiled milk. The preceding tests will serve to distinguish between raw and boiled milk, and also to ascertain if milk has been adulterated with diluted condensed milk. To what extent such an adulteration can be practiced without being detected by this or similar tests, has not been determined, but if a control test be made at the same time with a sample of milk of known purity, a small admixture of boiled (or diluted condensed) milk can doubtless be detected.[1]

296. Gelatine in cream. This method of adulteration is sometimes practiced in the city cream trade, to impart stiffness and an appearance of richness to the cream. To detect the gelatine, a quantity of the sus-

[1] See also Siats, Unters. landw. wicht. Stoffe, p. 60, and Molkerei-Ztg. (Hildesheim), 1899, p. 677.

pected cream is mixed with warm water, and acetic acid is added to precipitate the casein and fat (1.5 cc. of 10 per cent.-acetic acid per 10 cc. of cream is sufficient). The precipitate is filtered off, and a few drops of a strong *tannin* solution are added to the clear filtrate. Pure cream will give a slight precipitate, while in the presence of gelatine a copious precipitate will come down.

The picric-acid method has also been proposed for the detection of small quantities of gelatine in cream.[1]

297. Starch in cream. Starch is mentioned in the dairy literature as an adulterant of milk and cream. It is doubtful, however, if it is ever used for the purpose at the present time. In the case of ice-cream, on the other hand, a small quantity of corn starch is often added to thicken the milk used. It may in such a case be readily detected by means of the iodin reaction. A solusolution of iodin will produce a deep blue color in the presence of starch; a small amount of iodin is taken up by the cream before the blue coloration appears.

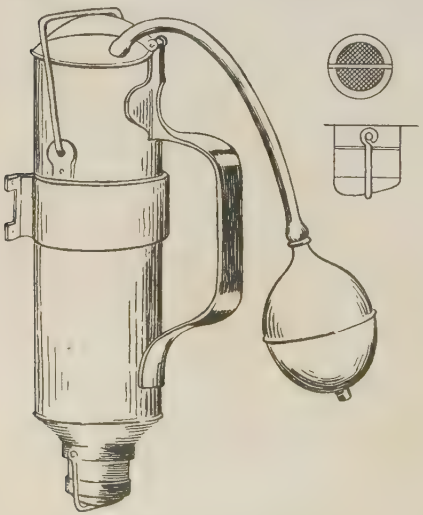

FIG. 62. The Wisconsin Milk Sediment Test.

[1] The Analyst, 1897, p. 320.

298. Macroscopic impurities (particles of hay, litter, woolen or cotton fibres, dung, etc.). These impurities may be separated by repeated dilution of the milk with pure distilled water, leaving the mixture undisturbed for a couple of hours each time before the liquid is syphoned off. When the milk has been entirely removed in this manner, the residue is filtered off, dried and weighed. A quart of milk or cream should not give any visible sediment on standing for several hours.

A simple and striking method of showing dirt in milk has been suggested by Gerber. About a pint of milk is poured into an inverted bottomless long-necked bottle, over the mouth of which a piece of cotton is placed. The milk will filter through, leaving the dirt on the cotton, which is then removed and can be shown to the producer of the milk.[1]

Milk Sediment Test Discs.

A modification of the apparatus used has been published by Wisconsin experiment station.[2] About one pint of milk is strained through a cotton disc which is held in the lower opening of a small metal cylinder (see Fig. 62). This disc is then removed and

[1] Hoard's Dairyman, Nov. 29, 1907.

[2] Bull. 195 and Circular 41.

furnishes evidence of the degree of cleanliness with which the milk has been handled. A rubber bulb is attached to the top of the cylinder to force the milk through the cotton disc.

DETECTION OF PRESERVATIVES IN DAIRY PRODUCTS.

299. a. **Boracic acid** (*borax, borates, preservaline, etc.*). 100 cc. of milk are made alkaline with a soda or potash solution, and then evaporated to dryness and incinerated. The ash is dissolved in water to which a little hydrochloric acid has been added, and the solution filtered. A strip of turmeric paper moistened with the filtrate will be colored reddish brown when dried at 100° C. on a watch glass, if boracic acid is present.

If a little alcohol is poured over the ash to which concentrated sulfuric acid has been added, and fire is set to the alcohol, this will burn with a yellowish green tint, especially noticeable if the ash is stirred with a glass rod and when the flame is about to go out.

300. The following modification of the first test given is said to show the presence of only a thousandth of a grain of borax in a drop of milk (about .15 per cent.):[3]

Place in a porcelain dish one drop of milk with two drops of strong hydrochloric acid and two drops of saturated turmeric tincture; dry this on the water bath, cool and add a drop of ammonia by means of a glass rod. A slaty blue color changing to green is produced if borax is present.[4]

301. b. **Bi-carbonate of soda.** 100 cc. of milk to which a few drops of alcohol are added, are evaporated and carefully incinerated; the proportion of carbonic acid in the ash as compared with that of milk of known purity is determined. If an apparatus for the deter-

[3] N. J. Dairy Commissioner, report, 1896 p. 36.

[4] See also par. 151.

mination of carbonic acid is available, like the Scheibler apparatus, etc., the per cent. of carbonic acid per gram of ash (and quart of milk) can be easily ascertained. Normal milk ash contains only a small amount of carbonic acid (less than 2 per cent.), presumably formed from the citric acid of the milk in the process of incineration.

The following qualitative test is easily made: To 10 cc. of milk add 10 cc. of alcohol and a little of a one per cent. solution of rosolic acid (corallin). Pure milk will give a brownish yellow color; milk to which soda has been added, a rose red color. A control experiment with milk of known purity should be made.

302. c. **Fluorids.** 100 cc. of milk are evaporated in a platinum or lead crucible, and incinerated; the ash is made strongly acid with concentrated sulfuric acid. If fluorids are present hydrofluoric acid will be generated on gentle heating and will be apparent from its etching a watch glass placed over the crucible.[1]

303. d. **Salicylic acid** (*salicylates, etc.*). 20 cc. of milk are acidulated with sulfuric acid and shaken with ether; the ether solution is evaporated, and the residue treated with alcohol and a little iron-chlorid solution; a deep violet color will be obtained in the presence of salicylic acid.

304. e. **Formaldehyde** (a forty-per cent. solution in water).

The following method by Hehner is stated to show the presence of one part of formaldehyde in 200,000

[1] *Chromates* in dairy products may be readily determined by the use of a silver-nitrate solution, see Molkerei-Ztg. (Berlin) 1899, p 603.

parts of milk: the milk is diluted with an equal volume of water, and strong H_2SO_4 (sp. gr. 1.82-1.84) is added. A violet ring is formed at the junction of the two liquids if formaldehyde is present; if not, a slight greenish tinge will be seen. The violet color is not obtained with milk containing over .05 per cent. formaldehyde.[1]

The same color reaction is obtained in the Babcock test and is easily recognized by persons familiar with milk testing when their attention has once been called to the characteristic color.

An adulteration of milk with formaldehyde may be readily detected by the following method, which will show the presence of only a trace of formaldehyde in the milk. 5 cc. of milk is measured into a white porcelain dish, and a similar quantity of water added. 10 cc. of HCl containing a trace of Fe_2Cl_6 is added, and the mixture is heated very slowly. If formaldehyde is present, a violet color will be formed.

[1] Chem. News, 1896, No. 71; Milchzeitung, 1896, 491; 1897, 40. 667; The Analyst, 1895, 152, 154, 157; 1896, 285.

305. GOVERNMENT STANDARDS OF PURITY FOR MILK AND ITS PRODUCTS.[1]

a. MILKS.

1. Milk is the fresh, clean, lacteal secretion obtained by the complete milking of one or more healthy cows, properly fed and kept, excluding that obtained within fifteen days before and ten days after calving, and contains not less than eight and one half (8.5) per cent. of solids not fat, and not less than three and one-quarter (3.25) per cent. of milk fat.

2. Blendid milk is milk modified in its composition so as to have a definite and stated percentage of one or more of its constituents.

3. Skim milk is milk from which a part or all of the cream has been removed and contains not less than nine and one-quarter (9.25) per cent. of milk solids.

4. Pasteurized milk is milk that has been heated below boiling but sufficiently to kill most of the active organisms present and immediately cooled to 50° Fehr. or lower.

5. Sterilized milk is milk that has been heated at the temperature of boiling water or higher for a length of time sufficient to kill all organisms present.

6. Condensed milk, evaporated milk is milk from which a considerable portion of water has been evaporated and contains not less than twenty-eight (28) per cent. of milk solids, of which not less than twenty-seven and five-tenths (27.5) per cent. is milk fat.

7. Sweetened condensed milk, sweetened evaporated milk, sweetened concentrated milk, is the product resulting from the evaporation of a considerable portion of the water from the whole, fresh, clean, lacteal secretion obtained by the complete milking of one or more healthy cows, properly fed and kept, excluding that obtained within fifteen days before and ten days after calving, to which sugar (sucrose) has

[1] Circular No. 19, Office of the Secretary, U. S. Dept. of Agriculture, June 26, 1906.

been added. It contains, all tolerances being allowed for not less than twenty-eight per cent (28%) of total milk solids, and not less than eight per cent (8%) of milk fat.

8. **Condensed skimmed milk**, evaporated skimmed milk, concentrated skimmed milk, is the product resulting from the evaporation of a considerable portion of the water from skimmed milk, and contains, all tolerances being allowed for, not less than twenty per cent (20%) of milk solids.

9. **Sweetened condensed skimmed milk**, sweetened evaporated skimmed milk, sweetened concentrated skimmed milk, is the product resulting from the evaporation of a considerable portion of the water from skimmed milk to which sugar (sucrose) has been added. It contains, all tolerances being allowed for, not less than twenty-eight per cent (28%) of milk solids.

10. **Dried milk** is the product resulting from the removal of water from milk, and contains, all tolerances being allowed for, not less than twenty-six per cent (26.0%) of milk fat, and not more than five per cent (5.0%) of moisture.

11. **Dried skimmed milk** is the product resulting from the removal of water from skimmed milk and contains, all tolerances being allowed for, not more than five per cent (5.0%) of moisture.

12. **Malted milk** is the product made by combining whole milk with the liquid separated from a mash of ground barley malt and wheat flour, with or without the addition of sodium chlorid, sodium bicarbonate, and potassium bicarbonate in such a manner as to secure the full enzymic action of the malt extract and by removing water. The resulting product contains not less than seven and one-half per cent (7.5%) of butterfat and not more than three and one-half per cent (3.5%) of moisture.

13. **Buttermilk** is the product that remains when butter is removed from milk or cream in the process of churning.

14. **Goat's milk, ewe's milk, etc.**, are the fresh, clean, lacteal secretions, free from colostrum, obtained by the complete milking of healthy animals other than cows, properly fed and kept, and conform in name to the species of animal from which they are obtained.

b. CREAM.

1. **Cream** is that portion of milk, rich in milk fat, which rises to the surface of milk on standing, or is separated from it by centrifugal force, is fresh and clean and contains not less than eighteen (18) per cent. of milk fat.

2. **Evaporated cream, clotted cream,** is cream from which a considerable portion of water has been evaporated.

c. MILK FAT OR BUTTER FAT.

1. **Milk fat, butter fat,** is the fat of milk and has the Reichert-Meissl number not less than twenty-four (24) and a specific gravity of not less than 0.905 $\left(\frac{40°\text{C.}}{40°\text{C.}}\right)$

d. BUTTER.

1. **Butter** is the clean, non-rancid product made by gathering in any manner the fat of fresh or ripened milk or cream into a mass, which also contains a small portion of the other milk constituents, with or without salt, and contains not less than eighty-two and five-tenths (82.5) per cent. of milk fat. By acts of Congress approved August 2, 1886, and May 9, 1902, butter may also contain added coloring matter.

2. **Renovated butter, process butter,** is the product made by melting butter and reworking, without the addition or use of chemicals or any substances except milk, cream, or salt, and contains not more than sixteen (16) per cent. of water and at least eighty-two and five-tenths (82.5) per cent. of milk fat.

e. CHEESE.

1. **Cheese** is the sound, solid, and ripened product made from milk or cream by coagulating the casein thereof with rennet or lactic acid, with or without the addition of ripening ferments and seasoning, and contains, in the water-free substance, not less than fifty (50) per cent. of milk fat. By act of Congress, approved June 6, 1896, cheese may also contain added coloring matter.

2. **Skim milk cheese** is the sound, solid, and ripened product, made from skim milk by coagulating the casein thereof with

rennet or lactic acid, with or without the addition of ripening ferments and seasoning.

3. **Goat's milk cheese, ewe's milk cheese, etc.,** are the sound, ripened products made from the milks of the animals specified, by coagulating the casein thereof with rennet or lactic acid, with or without the addition of ripening ferments and seasoning.

f. ICE CREAMS.

1. **Ice cream** is a frozen product made from cream and sugar, with or without a natural flavoring, and contains not less than fourteen (14) per cent. of milk fat.

2. **Fruit ice cream** is a frozen product made from cream, sugar, and sound, clean, mature fruits, and contains not less than twelve (12) per cent. of milk fat.

3. **Nut ice cream** is a frozen product made from cream, sugar, and sound, non-rancid nuts, and contains not less than twelve (12) per cent. of milk fat.

g. MISCELLANEOUS MILK PRODUCTS.

1. **Whey** is the product remaining after the removal of fat and casein from milk in the process of cheese-making.

2. **Kumiss** is the product made by the alcoholic fermentation of mare's or cow's milk.

307. SPECIFICATIONS FOR STANDARD BABCOCK GLASS WARE.

(Adopted by the Official Dairy Instructors' Association, 1911)

I. Milk Test Bottle. 8% 18 gram, so-called 6-inch.

Graduation: The total per cent graduation shall be 8. The graduated portion of the neck shall have a length of not less than 63.5 mm. (2½ inches). The graduation shall represent whole per cent, five-tenths per cent and tenths per cent. The tenths per cent graduations shall not be less than 3 mm. in length; the five-tenths per cent graduations shall be 1 mm. longer than the tenth per cent graduations, projecting 1 mm. to the left; the whole per cent graduations shall extend one-half way around the neck to the right and projecting 2 mm. to the left of the tenths per cent graduations. Each per cent graduation shall be numbered, the number being placed on the left of the scale. The error at any point of the scale shall not exceed one-tenth per cent.

Neck: The neck shall be cylindrical for at least 9 mm. below the lowest and above the highest graduation mark. The top of the neck shall be flared to a diameter of not less than 10 mm.

Bulb: The capacity of the bulb up to the junction of the neck shall not be less than 45 cc. The shape of the bulb may be either cylindrical or conical, with the smallest diameter at the bottom. If cylindrical, the outside diameter shall be between 34 and 36 mm.; if conical, the outside diameter of the base shall be between 31 and 33 mm., and the maximum diameter between 35 and 37 mm.

The Charge of the bottle shall be 18 grams.

The Total Height of the bottle shall be between 150 and 165 mm. (5⅞ and 6½ inches).

Each bottle shall bear a permanent identification number.

II. Cream Test Bottles. 50% 9-gram, so-called 6-inch, and 50% 9-gram, so-called 9-inch.

A. 50% 9- gram, so-called 6-inch.

Graduation: The total per cent graduation shall be 50. The graduated portion of the neck shall have a length of not less than 63.5 mm. (2½ inches). The graduation shall represent 5 per cent, 1 per cent and five-tenths per cent. The five-tenths per cent graduations shall be at least 3 mm. in length; the 1 per cent

graduations shall be 2 mm. longer than the five-tenths per cent graduations, projecting 2 mm. to the left; the 5 per cent graduations shall extend half way around the neck to the right and project 4 mm. to the left of the five-tenths per cent graduations. Each 5 per cent graduation shall be numbered, the number being placed on the left of the scale. The error at any point of the scale shall not exceed five-tenths per cent.

Neck: (Same as standard milk test bottle.) The neck shall be cylindrical for at least 9 mm. below the lowest and above the highest graduation mark. The top of the neck shall be flared to a diameter of not less than 10 mm.

Bulb: (Same as standard milk test bottle.) The capacity of the bulb up to the junction of the neck shall not be less than 45 cc. The shape of the bulb may be either cylindrical or conical, with the smallest diameter at the bottom. If cylindrical the outside diameter shall be between 34 and 36 mm.; if conical, the outside diameter of the base shall be between 31 and 33 mm. and the maximum diameter between 35 and 37 mm.

The Charge of the bottle shall be 9 grams. All bottles shall bear on top of the neck above the graduations in plainly legible characters, a mark defining the weight of the charge to be used (9 grams).

The Total Height of the bottle shall be between 150 and 165 mm. (5⅞ and 6½ inches). (Same as standard milk test bottles.)

Each bottle shall bear a permanent identification number.

B. 50% 9-gram, so-called 9-inch.

The same specifications in every detail as specified for the 50% 9-gram 6-inch cream test bottle shall apply to the 9-inch bottle, with the exception, however, that the total height of this bottle shall be between 210 and 225 mm. (8¼ and 8⅞ inches).

III. The Standard Babcock Pipette. Total length of pipette not more than 330 mm. (13¼ inches). Outside diameter of suction tube 6 to 8 mm. Length of suction tube 130 mm. Outside diameter of delivery tube, 4.5 to 5.5 mm. Length of delivery tube, 100 to 120 mm. Distance of graduation mark above bulb, 30 to 60 mm. Nozzle straight. Delivery 17.6 cc. of water at 20 degrees C. in 5 to 8 seconds.

In view of the fact that the skimmilk bottle can give only approximate quantitative results, it should be given no consideration as a standard bottle.

APPENDIX.

Table I. Composition of milk and its products.

	No. of analyses	Water	Fat	Casein and albumen	Milk sugar	Ash	Authority
		pr. ct.	pr. ct.	pr. ct.	pr. ct.	pr. ct.	
Cow's milk	793	87.17	3.69	3.55	4.88	.71	König[5]
" "	.....	87.75	3.40	3.50	4.60	.75	Fleischmann
" "	5,552	87.10	3.90	3.20[1]	5.10	.70	Van Slyke
" "	2,173	86.48	4.20	3.51[2]	.....	[3].71	Holland[6]
" "	200,000	87.10	3.90	3.40	4.85	.75	Richmond
Colostrum milk	42	74.57	3.59	17.64[4]	2.67	1.56	König[5]
Cream	43	68.82	22.66	3.76	4.23	.53	"
Cream, Cooley	203	73.90	17.60	.....	.....	.62	Holland[6]
Skim milk (gravity)	56	90.43	.87	3.26	4.74	.70	König[5]
" " "	354	90.52	.32	.....	.....	.....	Holland[6]
Skim milk (centrifugal)	.....	90.30	.10	3.55	5.25	.80	Van Slyke
Butter milk	57	90.12	1.09	4.03	4.04	.72	König[5]
" "	31	91.67	.27	.....	.....	.....	Holland[6]
Whey	46	93.38	.32	.86	4.79	.65	König[5]
"	.....	93.12	.27	.81	5.80		Van Slyke
Condensed milk, (no sugar added)	36	58.99	12.42	11.92	14.49	2.18	König[5]
Condensed milk, (sugar added)	64	25.61	10.35	11.79	50.06	2.19	"
Butter, salted	1,676	11.95	84.27	1.26		2.58	Woll
" sweet cream	10	12.93	84.53	.61	.68	1.25	König[5]
" sour cream	11	13.08	84.26	.81	.66	1.19	"
" unsalted	242	13.07	85.24	1.57		.12	Woll
" World's Fair, 1893	350	11.57	84.70	.95		2.78	Farrington
Cheese, cream	127	36.33	40.71	18.84	1.02	3.10	König[5]
" full cream	143	38.00	30.25	25.35	1.43	4.97	"
" cheddar, green	.....	36.84	33.83	23.72	5.61		Van Slyke
" cheddar, cured	27	34.38	32.71	26.38	2.95	3.58	Drew
" World's Fair Mam'th, 1893	1	32.06	34.43	28.00	5.51		Shutt
" half-skim	21	39.79	23.92	29.67	1.79	4.73	König[5]
" skim	41	46.00	11.65	34.06	3.42	4.87	"
" centrifugal skim	.....	50.5	1.2	43.1	.....	5.2	Storch

[1] .70 per cent. albumen.
[2] Forty-two analyses.
[3] Eight analyses.
[4] 13.60 per cent. albumen.
[5] Mostly European samples.
[6] Massachusetts' samples.

Legal Standards for Dairy Products

(Cir. 218. Bur. An. Ind. U. S. Dept. of Agric.)

States	Milk			Skim milk	Cream	Butter	Whole milk cheese	Condensed milk		Ice cream	
										Plain	Fruit and nut
	Total solids	Solids not fat	Fat	Total solids	Fat	Fat	Fat	Total solids	Fat	Fat	Fat
	Pr. ct.	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*
Cal	11.5	8.5	3.0	8.8	18.0	80.0	[1] 50	[2]	[2]	12	
Colo			3.0		[3] 16.0	80.0	[1] 50			14	12
Conn	11.75	8.5	3.25		16.0						
Dist. Col	12.5	9.0	3.5	9.3	20.0	83.0					
Fla	11.75	8.5	3.25	9.25	18.0	82.5	[1] 50	[4] 28.0	[4] 7.7	12	
Ga	11.75	8.5	3.25	9.25	18.0	82.5	[1] 50	28.0	[1] 27.66	14	12
Hawaii[5]	11.5	8.5	3.0					28.0	7.7		
Idaho	11.2	8.0	3.2	9.3	18.0	8.25	30	[2]	[2]	14	12
Ill	11.5	8.5	3.0	9.25	18.0	82.5	[1] 50	[2]	[2]	8	
Ind		8.5	3.25	9.26	18.0	82.5	[1] 50	28.0	[1] 27.5	8	
Iowa	12.0		3.0		16.0	[6] 80.0				12	
Kans	11.75	8.5	3.25	9.25	[3] 18.0	80.0	[1] 50	[2]	[2]	14	12
Ky	12.5	8.5	3.25	9.26	18.0	82.5	[1] 50	28.0	[1] 26.76	14	12
La		8.5	3.5	8.0	18.0			[2]	[2]		
Me	11.75	8.5	3.25		18.0						
Md	12.5		3.5	9.25	18.0			[2]	[2]	4	6
Mass	12.15		3.25	9.3	15.0						
Mich	12.5		3.0							12	
Minn	13.0	9.75	3.25		20.0		[1] 45	[2]	[2]	12	
Mo	12.0	8.75	3.25	9.25	18.0	8.25	[1] 50	28.0	[2] 7.76	14	
Mont	11.75	8.5	3.25		20.0	8.25	[1] 50			14	
Neb			3.0		18.0					14	12

[1] Percentage of fat based on total solids.
[2] Fat, 7.8 per cent; total solids plus fat, 34.3 per cent.
[3] For buttermaking, 25 per cent fat.
[4] This standard for sweetened condensed milk: "Evaporated milk," solids, 24 per cent; fat 7.8 per cent.
[5] No report; 1910 standard given.
[6] By weight.

LEGAL STANDARDS FOR DAIRY PRODUCTS—Continued

States	Milk			Skim milk	Cream	Butter	Whole milk cheese	Condensed milk		Ice cream	
										Plain	Fruit and nut
	Total solids	Solids not fat	Fat	Total solids	Fat	Fat	Fat	Total solids	Fat	Fat	Fat
	Pr. ct.	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*	*Pr. ct.*
N. H.	12.0	.....	.....	8.5	18.0	80.0	.....	.....	.....	[3] 14	.....
N. J.	11.5	.....	3.0	.....	16.0	.....	.....	.....	.....	.....	.....
N. Y.	11.5	.....	3.0	.....	18.0	.....	.....	[4]	[1] 25.0	.....	.....
Nev.	11.75	8.5	3.25	9.25	18.0	82.5	[1] 50	26.5	7.8	14	.....
N. C.	11.75	8.5	3.25	9.25	18.0	82.5	[1] 50	28.0	[1] 27.5	14	12
N. Dak.	12.0	9.0	3.0	.....	15.0	.....	.....	.....	.....	14	.....
Ohio	12.0	.....	3.0	.....	.....	[5] 80.0	.....	[6]	[1] 25.0	.....	.....
Okla.	12.51	9.5	3.0	.....	18.0	81.5	.....	.....	.....	14	.....
Ore.	.....	9.0	3.2	.....	20.0	.....	30.0	[7]	[7]	12	.....
Pa.	12.0	.....	3.25	.....	18.0	.....	32.0	.....	.....	8	6
Porto Rico	12.0	9.0	3.0	.....	.....	.....	.....	.....	.....	.....	.....
R. I.	12.0	.....	2.5	.....	.....	.....	.....	.....	.....	.....	.....
S. Dak.	.....	8.5	3.25	9.25	18.0	80.0	[1] 50	28.0	[1] 27.5	14	12
Tenn.	.....	8.5	3.25	.....	.....	.....	.....	.....	.....	.....	.....
Texas	.....	8.5	3.25	.....	.....	.....	.....	.....	.....	.....	.....
Utah	12.0	9.0	3.2	9.0	18.0	80.0	[1] 50	[2]	[2]	14	12
Vt.	[8] 12.5	9.25	.....	.....	.....	.....	.....	.....	.....	.....	.....
Va.	11.75	8.5	3.25	9.25	18.0	82.5	.....	[2]	[2]	8	.....
Wash.	12.0	8.75	3.25	9.3	18.0	.....	30	.....	.....	.....	.....
Wis.	.....	8.5	3.0	9.0	18.0	82.5	[1] 50	28.0	8.0	14	.....
Wyo.	.....	8.5	3.25	9.25	18.0	82.5	[1] 50	28.0	[9]	14	12

[1] Percentage of fat based on total solids.
[2] Fat, 7.8 per cent; total solids plus fat, 34.3 per cent.
[3] Not more than 0.2 per cent "filter."
[4] Must correspond to 11.5 per cent solids in crude milk.
[5] If artificially colored.
[6] Must correspond to 12 per cent solid in crude milk.
[7] 23–24 per cent solids, 7.9 per cent fat; 24–25 per cent solids, 7.8 per cent fat; 25–26 per cent solids, 7.7 per cent fat; 26 per cent solids, 7.6 per cent fat.
[8] In May and June, solids 12 per cent.
[9] Fat, 27.5 per cent of total solids.

Table III. Quevenne lactometer degrees corresponding to N. Y. Board of Health degrees. (See par. 114)

Bd. of Health degrees.	Quevenne scale.	Bd. of Health degrees.	Quevenne scale.	Bd. of Health degrees.	Quevenne scale.
60	17.4	81	23.5	101	29.3
61	17.7	82	23.8	102	29.6
62	18.0	83	24.1	103	29.9
63	18.3	84	24.4	104	30.2
64	18.6	85	24.6	105	30.5
65	18.8	86	24.9	106	30.7
66	19.1	87	25.2	107	31.0
67	19.4	88	25.5	108	31.3
68	19.7	89	25.8	109	31.6
69	20.0	90	26.1	110	31.9
70	20.3	91	26.4	111	32.2
71	20.6	92	26.7	112	32.5
72	20.9	93	27.0	113	32.8
73	21.2	94	27.3	114	33.1
74	21.5	95	27.6	115	33.4
75	21.7	96	27.8	116	33.6
76	22.0	97	28.1	117	33.9
77	22.3	98	28.4	118	34.2
78	22.6	99	28.7	119	34.5
79	22.9	100	29.0	120	34.8
80	23.2				

Table IV. Value of $\frac{100s-100}{s}$ for sp. gr. from 1.019 to 1.0369.

Sp. gr. (s)=	0.0000	0.0001	0.0002	0.0003	0.0004	0.0005	0.0006	0.0007	0.0008	0.000
1.019	1.864	1.874	1.884	1.894	1.903	1.913	1.922	1.932	1.941	1.951
1.020	1.961	1.970	1.980	1.990	1.999	2.009	2.018	2.028	2.038	2.047
1.021	2.057	2.066	2.076	2.086	2.095	2.105	2.114	2.124	2.133	2.143
1.022	2.153	2.162	2.172	2.181	2.191	2.200	2.210	2.220	2.229	2.239
1.023	2.249	2.258	2.267	2.277	2.286	2.296	2.306	2.315	2.325	2.334
1.024	2.344	2.353	2.363	2.372	2.382	2.391	2.401	2.410	2.420	2.430
1.025	2.439	2.449	2.458	2.468	2.477	2.487	2.496	2.506	2.515	2.525
1.026	2.534	2.544	2.553	2.563	2.573	2.582	2.591	2.601	2.610	2.620
1.027	2.629	2.638	2.648	2.657	2.667	2.676	2.686	2.695	2.705	2.714
1.028	2.724	2.733	2.743	2.752	2.762	2.771	2.781	2.790	2.799	2.809
1.029	2.818	2.828	2.837	2.847	2.856	2.865	2.875	2.884	2.893	2.903
1.030	2.913	2.922	2.931	2.941	2.951	2.960	2.969	2.979	2.988	2.997
1.031	3.007	3.016	3.026	3.035	3.044	3.054	3.063	3.072	3.082	3.091
1.032	3.101	3.110	3.120	3.129	3.138	3.148	3.157	3.166	3.176	3.185
1.033	3.195	3.204	3.213	3.223	3.232	3.241	3.251	3.260	3.269	3.279
1.034	3.288	3.298	3.307	3.316	3.326	3.335	3.344	3.354	3.363	3.373
1.035	3.382	3.391	3.400	3.410	3.419	3.428	3.438	3.447	3.456	3.466
1.036	3.475	3.484	3.494	3.503	3.512	3.521	3.531	3.540	3.549	3.559

(See directions for use,

Table V. Correction-table for specific gravity of milk.

Lactometer reading.	Temperature of milk (in degrees Fahrenheit).									
	51	52	53	54	55	56	57	58	59	60
20	19.3	19.4	19.4	19.5	19.6	19.7	19.8	19.9	19.9	20.0
21	20.3	20.3	20.4	20.5	20.6	20.7	20.8	20.9	20.9	21.0
22	21.3	21.3	21.4	21.5	21.6	21.7	21.8	21.9	21.9	22.0
23	22.3	22.3	22.4	22.5	22.6	22.7	22.8	22.8	22.9	23.0
24	23.3	23.3	23.4	23.5	23.6	23.6	23.7	23.8	23.9	24.0
25	24.2	24.3	24.4	24.5	24.6	24.6	24.7	24.8	24.9	25.0
26	25.2	25.2	25.3	25.4	25.5	25.6	25.7	25.8	25.9	26.0
27	26.2	26.2	26.3	26.4	26.5	26.6	26.7	26.8	26.9	27.0
28	27.1	27.2	27.3	27.4	27.5	27.6	27.7	27.8	27.9	28.0
29	28.1	28.2	28.3	28.4	28.5	28.6	28.7	28.8	28.9	29.0
30	29.1	29.1	29.2	29.3	29.4	29.6	29.7	29.8	29.9	30.0
31	30.0	30.1	30.2	30.3	30.4	30.5	30.6	30.8	30.9	31.0
32	31.0	31.1	31.2	31.3	31.4	31.5	31.6	31.7	31.9	32.0
33	31.9	32.0	32.1	32.3	32.4	32.5	32.6	32.7	32.9	33.0
34	32.9	33.0	33.1	33.2	33.3	33.5	33.6	33.7	33.9	34.0
35	33.8	33.9	34.0	34.2	34.3	34.5	34.6	34.7	34.9	35.0
	61	62	63	64	65	66	67	68	69	70
20	20.1	20.2	20.2	20.3	20.4	20.5	20.6	20.7	20.9	21.0
21	21.1	21.2	21.3	21.4	21.5	21.6	21.7	21.8	22.0	22.1
22	22.1	22.2	22.3	22.4	22.5	22.6	22.7	22.8	23.0	23.1
23	23.1	23.2	23.3	23.4	23.5	23.6	23.7	23.8	24.0	24.1
24	24.1	24.2	24.3	24.4	24.5	24.6	24.7	24.9	25.0	25.1
25	25.1	25.2	25.3	25.4	25.5	25.6	25.7	25.9	26.0	26.1
26	26.1	26.2	26.3	26.5	26.6	26.7	26.8	27.0	27.1	27.2
27	27.1	27.3	27.4	27.5	27.6	27.7	27.8	28.0	28.1	28.2
28	28.1	28.3	28.4	28.5	28.6	28.7	28.8	29.0	29.1	29.2
29	29.1	29.3	29.4	29.5	29.6	29.7	29.9	30.1	30.2	30.3
30	30.1	30.3	30.4	30.5	30.7	30.8	30.9	31.1	31.2	31.3
31	31.2	31.3	31.4	31.5	31.7	31.8	31.9	32.1	32.2	32.4
32	32.2	32.3	32.5	32.6	32.7	32.9	33.0	33.	33.3	33.4
33	33.2	33.3	33.5	33.6	33.8	33.9	34.0	34.2	34.3	34.5
34	34.2	34.3	34.5	34.6	34.8	34.9	35.0	35.2	35.3	35.5
35	35.2	35.3	35.5	35.6	35.8	35.9	36.1	36.2	36.4	36.5

DIRECTIONS.— Bring the temperature of the milk to within 10° of 60° F. Take the reading of the lactometer and that of the temperature of the milk; find the former in the first vertical column of the table and the latter in the first horizontal row of figures; the figure where the horizontal and vertical columns meet is the corrected lactometer reading; e.g., observed, 31.0 at 67° F.; corrected reading, 31.9

Table VI. Per cent. of solids not fat, corresponding to 0 to 6 per cent. of fat, and lactometer readings of 26 to 36. (See directions for use, par. 120)

Per cent. of fat.	Lactometer readings at 60° F.											Per cent. of fat.
	26	27	28	29	30	31	32	33	34	35	36	
0	6.50	6.75	7.00	7.25	7.50	7.75	8.00	8.25	8.50	8.75	9.00	0
0.1	6.52	6.77	7.02	7.27	7.52	7.77	8.02	8.27	8.52	8.77	9.02	0.1
0.2	6.54	6.79	7.04	7.29	7.54	7.79	8.04	8.29	8.54	8.79	9.04	0.2
0.3	6.56	6.81	7.06	7.31	7.56	7.81	8.06	8.31	8.56	8.81	9.06	0.3
0.4	6.58	6.83	7.08	7.33	7.58	7.83	8.08	8.33	8.58	8.83	9.08	0.4
0.5	6.60	6.85	7.10	7.35	7.60	7.85	8.10	8.35	8.60	8.85	9.10	0.5
0.6	6.62	6.87	7.12	7.37	7.62	7.87	8.12	8.37	8.62	8.87	9.12	0.6
0.7	6.64	6.89	7.14	7.39	7.64	7.89	8.14	8.39	8.64	8.89	9.14	0.7
0.8	6.66	6.91	7.16	7.41	7.66	7.91	8.16	8.41	8.66	8.91	9.16	0.8
0.9	6.68	6.93	7.18	7.43	7.68	7.93	8.18	8.43	8.68	8.93	9.18	0.9
1.0	6.70	6.95	7.20	7.45	7.70	7.95	8.20	8.45	8.70	8.95	9.20	1.0
1.1	6.72	6.97	7.22	7.47	7.72	7.97	8.22	8.47	8.72	8.97	9.22	1.1
1.2	6.74	6.99	7.24	7.49	7.74	7.99	8.24	8.49	8.74	8.99	9.24	1.2
1.3	6.76	7.01	7.26	7.51	7.76	8.01	8.26	8.51	8.76	9.01	9.26	1.3
1.4	6.78	7.03	7.28	7.53	7.78	8.03	8.28	8.53	8.78	9.03	9.28	1.4
1.5	6.80	7.05	7.30	7.55	7.80	8.05	8.30	8.55	8.80	9.05	9.30	1.5
1.6	6.82	7.07	7.32	7.57	7.82	8.07	8.32	8.57	8.82	9.07	9.32	1.6
1.7	6.84	7.09	7.34	7.59	7.84	8.09	8.34	8.59	8.84	9.09	9.34	1.7
1.8	6.86	7.11	7.36	7.61	7.86	8.11	8.36	8.61	8.86	9.11	9.37	1.8
1.9	6.88	7.13	7.38	7.63	7.88	8.13	8.38	8.63	8.88	9.13	9.39	1.9
2.0	6.90	7.15	7.40	7.65	7.90	8.15	8.40	8.66	8.91	9.16	9.41	2.0
2.1	6.92	7.17	7.42	7.67	7.92	8.17	8.42	8.68	8.93	9.18	9.43	2.1
2.2	6.94	7.19	7.44	7.69	7.94	8.19	8.44	8.70	8.95	9.20	9.45	2.2
2.3	6.96	7.21	7.46	7.71	7.96	8.21	8.46	8.72	8.97	9.22	9.47	2.3
2.4	6.98	7.23	7.48	7.73	7.98	8.23	8.48	8.74	8.99	9.24	9.49	2.4
2.5	7.00	7.25	7.50	7.75	8.00	8.25	8.50	8.76	9.01	9.26	9.51	2.5
2.6	7.02	7.27	7.52	7.77	8.02	8.27	8.52	8.78	9.03	9.28	9.53	2.6
2.7	7.04	7.29	7.54	7.79	8.04	8.29	8.54	8.80	9.05	9.30	9.55	2.7
2.8	7.06	7.31	7.56	7.81	8.06	8.31	8.57	8.82	9.07	9.32	9.57	2.8
2.9	7.08	7.33	7.58	7.83	8.08	8.33	8.59	8.84	9.09	9.34	9.59	2.9

Table VI. Per cent. of solids not fat (*Continued*).

Per cent. of fat.	Lactometer Readings at 60° F.											Per cent. of fat.
	26	27	28	29	30	31	32	33	34	35	36	
3.0	7.10	7.35	7.60	7.85	8.10	8.36	8.61	8.86	9.11	9.36	9.61	3.0
3.1	7.12	7.37	7.62	7.87	8.13	8.38	8.63	8.88	9.13	9.38	9.64	3.1
3.2	7.14	7.39	7.64	7.89	8.15	8.40	8.65	8.90	9.15	9.41	9.66	3.2
3.3	7.16	7.41	7.66	7.92	8.17	8.42	8.67	8.92	9.18	9.43	9.68	3.3
3.4	7.18	7.43	7.69	7.94	8.19	8.44	8.69	8.94	9.20	9.45	9.70	3.4
3.5	7.20	7.45	7.71	7.96	8.21	8.46	8.71	8.96	9.22	9.47	9.72	3.5
3.6	7.22	7.48	7.73	7.98	8.23	8.48	8.73	8.98	9.24	9.49	9.74	3.6
3.7	7.24	7.50	7.75	8.00	8.25	8.50	8.75	9.00	9.26	9.51	9.76	3.7
3.8	7.26	7.52	7.77	8.02	8.27	8.52	8.77	9.02	9.28	9.53	9.78	3.8
3.9	7.28	7.54	7.79	8.04	8.29	8.54	8.79	9.04	9.30	9.55	9.80	3.9
4.0	7.30	7.56	7.81	8.06	8.31	8.56	8.81	9.06	9.32	9.57	9.83	4.0
4.1	7.32	7.58	7.83	8.08	8.33	8.58	8.83	9.08	9.34	9.59	9.85	4.1
4.2	7.34	7.60	7.85	8.10	8.35	8.60	8.85	9.11	9.36	9.62	9.87	4.2
4.3	7.36	7.62	7.87	8.12	8.37	8.62	8.88	9.13	9.38	9.64	9.89	4.3
4.4	7.38	7.64	7.89	8.14	8.39	8.64	8.90	9.15	9.40	9.66	9.91	4.4
4.5	7.40	7.66	7.91	8.16	8.41	8.66	8.92	9.17	9.42	9.68	9.93	4.5
4.6	7.43	7.68	7.93	8.18	8.43	8.68	8.94	9.19	9.44	9.70	9.95	4.6
4.7	7.45	7.70	7.95	8.20	8.45	8.70	8.96	9.21	9.46	9.72	9.97	4.7
4.8	7.47	7.72	7.97	8.22	8.47	8.72	8.98	9.23	9.48	9.74	9.99	4.8
4.9	7.49	7.74	7.99	8.24	8.49	8.74	9.00	9.25	9.50	9.76	10.01	4.9
5.0	7.51	7.76	8.01	8.26	8.51	8.76	9.02	9.27	9.52	9.78	10.03	5.0
5.1	7.53	7.78	8.03	8.28	8.53	8.79	9.04	9.29	9.54	9.80	10.05	5.1
5.2	7.55	7.80	8.05	8.30	8.55	8.81	9.06	9.31	9.56	9.82	10.07	5.2
5.3	7.57	7.82	8.07	8.32	8.57	8.83	9.08	9.33	9.58	9.84	10.09	5.3
5.4	7.59	7.84	8.09	8.34	8.60	8.85	9.10	9.36	9.61	9.86	10.11	5.4
5.5	7.61	7.86	8.11	8.36	8.62	8.87	9.12	9.38	9.63	9.88	10.13	5.5
5.6	7.63	7.88	8.13	8.39	8.64	8.89	9.15	9.40	9.65	9.90	10.15	5.6
5.7	7.65	7.90	8.15	8.41	8.66	8.91	9.17	9.42	9.67	9.92	10.17	5.7
5.8	7.67	7.92	8.17	8.43	8.68	8.94	9.19	9.44	9.69	9.94	10.19	5.8
5.9	7.69	7.94	8.20	8.45	8.70	8.96	9.21	9.46	9.71	9.96	10.22	5.9
6.0	7.71	7.96	8.22	8.47	8.72	8.98	9.23	9.48	9.73	9.98	10.24	6.0

Directions for Use of Tables VII, VIII, IX, and XI.

TABLES VII, and VIII. Find the test of the milk in table VII or of cream in table VIII; the first or last horizontal row of figures, the amounts of fat in ten thousand, thousands, hundreds, tens, and units of pounds of milk are then given in this vertical column. By adding the corresponding figures for any given quantity of milk or of cream, the total quantity of butter fat contained therein is obtained.

Example: How many pounds of fat is contained in 8925 lbs. of milk testing 3.65 per cent.? On p 264, second column the test **3.65** is found, and by going downward in this column we have:

8000 lbs.....	292. lbs.
900 lbs.....	32.9 lbs.
20 lbs.....	.7 lbs.
5 lbs.....	.2 lbs.
8925 lbs. of milk.	325.8 lbs. of fat.

8925 lbs. of milk testing 3.65 per cent., therefore, contains 325.8 lbs. of butter fat.

TABLE IX. The price per pound is given in the outside vertical columns, and the weight of butter fat in the upper and lower horizontal row of figures. The corresponding tens of pounds are found by moving the decimal point one place to the left, the units, by moving it two, and the tenths of a pound, by moving it three places to the left. The use of the table is, otherwise, as explained above.

Example: How much money is due for 325.8 lbs. of butter fat at 15½ cents per pound? In the horizontal row of figures beginning with 15½ on p. 247, we find:

300 lbs.....	$46.50
20 lbs.....	3.10
5 lbs.....	.77
.8 lbs.....	.12
325.8 lbs.	$50.49

325.8 lbs. of butter fat at 15½ cents per pound, therefore, is worth $50.49.

TABLE XI. Find the test of milk in the upper or lower horizontal row of figures. The amounts of butter likely to be made from ten thousand, thousands, hundreds, tens, and units of pounds of milk are then given in this vertical column. The use of the table is, otherwise, as explained above in case of table VII.

Example: How much butter will 5845 lbs. of milk testing 3.8 per cent. be apt to make under good creamery conditions? In the column headed **3.8**, we find:

5000 lbs.....	209.0 lbs.
800 lbs.....	33.4 lbs.
40 lbs.....	1.7 lbs.
5 lbs.....	.2 lbs.
5845 lbs.	244.3 lbs.

5845 lbs. of milk testing 3.8 per cent. of fat will make about 244.3 lbs. of butter, under conditions similar to those explained in par 220.

Table VII. Pounds of fat in 1 to 10,000 lbs. of milk, testing 3.0 to 5.35 per cent. (See directions for use, p. 266)

Test.	3.00	3.05	3.10	3.15	3.20	3.25	3.30	3.35	3.40	3.45	3.50	3.55	Test.
Milk lbs.													Milk lbs.
10,000	300	305	310	315	320	325	330	335	340	345	350	355	10,000
9,000	270	275	279	284	289	293	297	302	306	311	315	320	9,000
8,000	240	244	248	252	256	260	264	268	272	276	280	284	8,000
7,000	210	214	217	221	224	228	231	235	238	242	245	249	7,000
6,000	180	183	186	189	192	195	198	201	204	207	210	213	6,000
5,000	150	153	155	158	160	163	165	168	170	173	175	178	5,000
4,000	120	122	124	126	128	130	132	134	136	138	140	142	4,000
3,000	90.0	91.5	93.0	94.5	96.0	97.5	99.0	101	102	104	105	107	3,000
2,000	60.0	61.0	62.0	63.0	64.0	65.0	66.0	67.0	68.0	69.0	70.0	71.0	2,000
1,000	30.0	30.5	31.0	31.5	32.0	32.5	33.0	33.5	34.0	34.5	35.0	35.5	1,000
900	27.0	27.5	27.9	28.4	28.8	29.3	29.7	30.2	30.6	31.1	31.5	32.0	900
800	24.0	24.4	24.8	25.2	25.7	26.0	26.4	26.8	27.2	27.6	28.0	28.4	800
700	21.0	21.4	21.7	22.1	22.4	22.8	23.1	23.5	23.8	24.2	24.5	24.9	700
600	18.0	18.3	18.6	18.9	19.2	19.5	19.8	20.1	20.4	20.7	21.0	21.3	600
500	15.0	15.3	15.5	15.8	16.0	16.3	16.5	16.8	17.0	17.3	17.5	17.8	500
400	12.0	12.2	12.4	12.6	12.8	13.0	13.2	13.4	13.6	13.8	14.0	14.2	400
300	9.0	9.2	9.3	9.5	9.6	9.8	9.9	10.1	10.2	10.4	10.5	10.7	300
200	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	200
100	3.0	3.1	3.1	3.2	3.2	3.3	3.3	3.4	3.4	3.5	3.5	3.6	100
90	2.7	2.8	2.8	2.8	2.9	2.9	3.0	3.0	3.1	3.1	3.2	3.2	90
80	2.4	2.4	2.5	2.5	2.6	2.6	2.6	2.7	2.7	2.8	2.8	2.8	80
70	2.1	2.1	2.2	2.2	2.2	2.3	2.3	2.3	2.4	2.4	2.5	2.5	70
60	1.8	1.8	1.9	1.9	1.9	2.0	2.0	2.0	2.0	2.1	2.1	2.1	60
50	1.5	1.5	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.7	1.8	1.8	50
40	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.3	1.4	1.4	1.4	1.4	40
30	.9	.9	.9	.9	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1	30
20	.6	.6	.6	.6	.6	.7	.7	.7	.7	.7	.7	.7	20
10	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.4	.4	10
9	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	9
8	.2	.2	.2	.3	.3	.3	.3	.3	.3	.3	.3	.3	8
7	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	7
6	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	6
5	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	5
4	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	4
3	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	3
2	.1	.1	.1	.1	.1	1	.1	.1	.1	.1	.1	.1	2
1													1
Test.	3.00	3.05	3.10	3.15	3.20	3.25	3.30	3.35	3.40	3.45	3.50	3.55	Test.

Table VII. Pounds of fat in 1 to 10,000 lbs. of milk (*Continued*).

Test.	3.60	3.65	3.70	3.75	3.80	3.85	3.90	3.95	4.00	4.05	4.10	4.15	Test.
Milk lbs.													Milk lbs.
10,000	360	365	370	375	380	385	390	395	400	405	410	415	10,000
9,000	324	329	333	338	342	347	351	356	360	365	369	374	9,000
8,000	288	292	296	300	304	308	312	316	320	324	328	332	8,000
7,000	252	256	259	263	266	270	273	277	280	284	287	291	7,000
6,000	216	219	222	225	228	231	234	237	240	243	246	249	6,000
5,000	180	183	185	188	190	193	195	198	200	203	205	208	5,000
4,000	144	146	148	150	152	154	156	158	160	162	164	166	4,000
3,000	108	110	111	113	114	116	117	119	120	122	123	125	3,000
2,000	72.0	73.0	74.0	75.0	76.0	77.0	78.0	79.0	80.0	81.0	82.0	83.0	2,000
1,000	36.0	36.5	37.0	37.5	38.0	38.5	39.0	39.5	40.0	40.5	41.0	41.5	1,000
900	32.4	32.9	33.3	33.8	34.2	34.7	35.1	35.6	36.0	36.5	36.9	37.4	900
800	28.8	29.2	29.6	30.0	30.4	30.8	31.2	31.6	32.0	32.4	32.8	33.2	800
700	25.2	25.6	25.9	26.3	26.6	27.0	27.3	27.7	28.0	28.4	28.7	29.1	700
600	21.6	21.9	22.2	22.5	22.8	23.1	23.4	23.7	24.0	24.3	24.6	24.9	600
500	18.0	18.3	18.5	18.8	19.0	19.3	19.5	19.8	20.0	20.3	20.5	20.8	500
400	14.4	14.6	14.8	15.0	15.2	15.4	15.6	15.8	16.0	16.2	16.4	16.6	400
300	10.8	11.0	11.1	11.3	11.4	11.6	11.7	11.9	12.0	12.2	12.3	12.5	300
200	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8.0	8.1	8.2	8.3	200
100	3.6	3.7	3.7	3.8	3.8	3.9	3.9	4.0	4.0	4.1	4.1	4.2	100
90	3.2	3.3	3.3	3.4	3.4	3.5	3.5	3.6	3.6	3.7	3.7	3.7	90
80	2.9	2.9	3.0	3.0	3.0	3.1	3.1	3.2	3.2	3.2	3.3	3.3	80
70	2.5	2.6	2.6	2.6	2.7	2.7	2.7	2.8	2.8	2.8	2.9	2.9	70
60	2.2	2.2	2.2	2.3	2.3	2.3	2.3	2.4	2.4	2.4	2.5	2.5	60
50	1.8	1.8	1.9	1.9	1.9	1.9	2.0	2.0	2.0	2.0	2.1	2.1	50
40	1.4	1.5	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.6	1.7	40
30	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1 2	1.2	1.2	1.2	30
20	.7	.7	.7	.8	.8	.8	.8	.8	.8	.8	.8	.8	20
10	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	10
9	.3	.3	.3	.3	.3	.3	.4	.4	.4	.4	.4	.4	9
8	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	8
7	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	7
6	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	6
5	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	5
4	.1	.1	.1	.2	.2	.2	.2	.2	.2	.2	.2	.2	4
3	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	3
2	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	2
1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Test.	3.60	3.65	3.70	3.75	3.80	3.85	3.90	3.95	4.00	4.05	4.10	4.15	Test.

Table VII. Pounds of fat in 1 to 10,000 lbs. of milk (*Continued*).

Test.	4.20	4.25	4.30	4.35	4.40	4.45	4.50	4.55	4.60	4.65	4.70	4.75	Test.
Milk lbs.													Milk lbs.
10,000	420	425	430	435	440	445	450	455	460	465	470	475	10,000
9,000	378	383	387	392	396	401	405	410	414	419	423	428	9,000
8,000	336	340	344	348	352	356	360	364	368	372	376	380	8,000
7,000	294	298	301	305	308	312	315	319	322	326	329	333	7,000
6,000	252	255	258	261	264	267	270	273	276	279	282	285	6,000
5,000	210	213	215	218	220	223	225	228	230	233	235	238	5,000
4,000	168	170	172	174	176	178	180	182	184	186	188	190	4,000
3,000	126	128	129	131	132	134	135	137	138	140	141	143	3,000
2,000	84.0	85.0	86.0	87.0	88.0	89.0	90.0	91.0	92.0	93.0	94.0	95.0	2,000
1,000	42.0	42.5	43.0	43.5	44.0	44.5	45.0	45.5	46.0	46.5	47.0	47.5	1,000
900	37.8	38.3	38.7	39.2	39.6	40.1	40.5	41.0	41.4	41.9	42.3	42.8	900
800	33.6	34.0	34.4	34.8	35.2	35.6	36.0	36.4	36.8	37.2	37.6	38.0	800
700	29.4	29.8	30.1	30.5	30.8	31.2	31.5	31.9	32.2	32.6	32.9	33.3	700
600	25.2	25.5	25.8	26.1	26.4	26.7	27.0	27.3	27.6	27.9	28.2	28.5	600
500	21.0	21.3	21.5	21.8	22.0	22.3	22.5	22.8	23.0	23.3	23.5	23.8	500
400	16.8	17.0	17.2	17.4	17.6	17.8	18.0	18.2	18.4	18.6	18.8	19.0	400
300	12.6	12.8	12.9	13.1	13.2	13.4	13.5	13.7	13.8	14.0	14.1	14.3	300
200	8.4	8.5	8.6	8.7	8.8	8.9	9.0	9.1	9.2	9.3	9.4	9.5	200
100	4.2	4.3	4.3	4.4	4.4	4.5	4.5	4.6	4.6	4.7	4.7	4.8	100
90	3.8	3.8	3.9	3.9	4.0	4.0	4.1	4.1	4.1	4.2	4.2	4.3	90
80	3.4	3.4	3.4	3.5	3.5	3.6	3.6	3.6	3.7	3.7	3.8	3.8	80
70	2.9	3.0	3.0	3.0	3.1	3.1	3.2	3.2	3.2	3.3	3.3	3.3	70
60	2.5	2.6	2.6	2.6	2.6	2.7	2.7	2.7	2.8	2.8	2.8	2.9	60
50	2.1	2.1	2.2	2.2	2.2	2.2	2.3	2.3	2.3	2.3	2.4	2.4	50
40	1.7	1.7	1.7	1.7	1.8	1.8	1.8	1.8	1.8	1.9	1.9	1.9	40
30	1.3	1.3	1.3	1.3	1.3	1.3	1.4	1.4	1.4	1.4	1.4	1.4	30
20	.8	.9	.9	.9	.9	.9	.9	.9	.9	.9	.9	1.0	20
10	.4	.4	.4	.4	.4	.4	.5	.5	.5	.5	.5	.5	10
9	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	9
8	.3	.3	.3	.3	.4	.4	.4	.4	.4	.4	.4	.4	8
7	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	7
6	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	6
5	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	5
4	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	4
3	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	3
2	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	2
1	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	1
Test.	4.20	4.25	4.30	4.35	4.40	4.45	4.50	4.55	4.60	4.65	4.70	4.75	Test.

Table VII. Pounds of fat in 1 to 10,000 lbs. of milk (*Continued*).

Test.	4.80	4.85	4.90	4.95	5.00	5.05	5.10	5.15	5.20	5.25	5.30	5.35	Test.
Milk lbs.													Milk lbs.
10,000	480	485	490	495	500	505	510	515	520	525	530	535	10,000
9,000	432	437	441	446	450	455	459	464	468	473	477	482	9,000
8,000	384	388	392	396	400	404	408	412	416	420	424	428	8,000
7,000	336	340	343	347	350	354	357	361	364	368	371	375	7,000
6,000	288	291	294	297	300	303	306	309	312	315	318	321	6,000
5,000	240	243	245	248	250	253	255	258	260	263	265	268	5,000
4,000	192	194	196	198	200	202	204	206	208	210	212	214	4,000
3,000	144	146	147	149	150	152	153	155	156	158	159	161	3,000
2,000	96.0	97.0	98.0	99.0	100	101	102	103	104	105	106	107	2,000
1,000	48.0	48.5	49.0	49.5	50.0	50.5	51.0	51.5	52.0	52.5	53.0	53.5	1,000
900	43.2	43.7	44.1	44.6	45.0	45.5	45.7	46.4	46.8	47.3	47.7	48.2	900
800	38.4	38.8	39.2	39.6	40.0	40.4	40.8	41.2	41.6	42.0	42.4	42.8	800
700	33.6	34.0	34.3	34.7	35.0	35.4	35.7	36.1	36.4	36.8	37.1	37.5	700
600	28.8	29.1	29.4	29.7	30.0	30.3	30.6	30.9	31.2	31.5	31.8	32.1	600
500	24.0	24.3	24.5	24.8	25.0	25.3	25.5	25.8	26.0	26.3	26.5	26.8	500
400	19.2	19.4	19.6	19.8	20.0	20.2	20.4	20.6	20.8	21.0	21.2	21.4	400
300	14.4	14.6	14.7	14.9	15.0	15.2	15.3	15.5	15.6	15.8	15.9	16.1	300
200	9.6	9.7	9.8	9.9	10.0	10.1	10.2	10.3	10.4	10.5	10.6	10.7	200
100	4.8	4.9	4.9	5.0	5.0	5.1	5.1	5.2	5.2	5.3	5.3	5.4	100
90	4.3	4.4	4.4	4.5	4.5	4.5	4.6	4.6	4.7	4.7	4.8	4.8	90
80	3.8	3.9	3.9	4.0	4.0	4.0	4.1	4.1	4.2	4.2	4.2	4.3	80
70	3.4	3.4	3.4	3.5	3.5	3.5	3.6	3.6	3.6	3.7	3.7	3.7	70
60	2.9	2.9	2.9	3.0	3.0	3.0	3.1	3.1	3.1	3.2	3.2	3.2	60
50	2.4	2.4	2.5	2.5	2.5	2.5	2.6	2.6	2.6	2.6	2.7	2.7	50
40	1.9	1.9	2.0	2.0	2.0	2.0	2.0	2.1	2.1	2.1	2.1	2.1	40
30	1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.6	30
20	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.1	20
10	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	.5	10
9	.4	.4	.4	.4	.5	.5	.5	.5	.5	.5	.5	.5	9
8	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	.4	8
7	.3	.3	.3	.3	.4	.4	.4	.4	.4	.4	.4	.4	7
6	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	6
5	.2	.2	.2	.2	.3	.3	.3	.3	.3	.3	.3	.3	5
4	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	4
3	.1	.1	.1	.1	.2	.2	.2	.2	.2	.2	.2	.2	3
2	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	2
1	.....	.....	.....	.....	.1	.1	.1	.1	.1	.1	.1	.1	1
Test.	4.80	4.85	4.90	4.95	5.00	5.05	5.10	5.15	5.20	5.25	5.30	5.35	Test.

Table VIII. Pounds of fat in 1 to 1000 lbs. of cream testing 12.0 to 50.0 per cent. fat.

(See directions for use, p. 266)

Cream lbs. \ Test.	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1000	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300
900	108	117	126	135	144	153	162	171	180	189	198	207	216	225	234	243	252	261	270
800	96	104	112	120	128	136	144	152	160	168	176	184	192	200	208	216	224	232	240
700	84	91	98	105	112	119	126	133	140	147	154	161	168	175	182	189	196	203	210
600	72	78	84	90	96	102	108	114	120	126	132	138	144	150	156	162	168	174	180
500	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150
400	48	52	56	60	64	68	72	76	80	84	88	92	96	100	104	108	112	116	120
300	36	39	42	45	48	51	54	57	60	63	66	69	72	75	78	81	84	87	90
200	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60
100	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
90	10.8	11.7	12.6	13.5	14.4	15.3	16.2	17.1	18.0	18.9	19.8	20.7	21.6	22.5	23.4	24.3	25.2	26.1	27.0
80	9.6	10.4	11.2	12.0	12.8	13.6	14.4	15.2	16.0	16.8	17.6	18.4	19.2	20.0	20.8	21.6	22.4	23.2	24.0
70	8.4	9.1	9.8	10.5	11.2	11.9	12.6	13.3	14.0	14.7	15.4	16.1	16.8	17.5	18.2	18.9	19.6	20.3	21.0
60	7.2	7.8	8.4	9.0	9.6	10.2	10.8	11.4	12.0	12.6	13.2	13.8	14.4	15.0	15.6	16.2	16.8	17.4	18.0
50	6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	12.5	13.0	13.5	14.0	14.5	15.0
40	4.8	5.2	5.6	6.0	6.4	6.8	7.2	7.6	8.0	8.4	8.8	9.2	9.6	10.0	10.4	10.8	11.2	11.6	12.0
30	3.6	3.9	4.2	4.5	4.8	5.1	5.4	5.7	6.0	6.3	6.6	6.9	7.2	7.5	7.8	8.1	8.4	8.7	9.0
20	2.4	2.6	2.8	3.0	3.2	3.4	3.6	3.8	4.0	4.2	4.4	4.6	4.8	5.0	5.2	5.4	5.6	5.8	6.0
10	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0
9	1.08	1.17	1.26	1.35	1.44	1.53	1.62	1.71	1.80	1.89	1.98	2.07	2.16	2.25	2.34	1.43	2.52	2.61	2.70
8	.96	1.04	1.12	1.20	1.28	1.36	1.44	1.52	1.60	1.68	1.76	1.84	1.92	2.00	2.08	2.16	2.24	2.32	2.40
7	.84	.91	.98	1.05	1.12	1.19	1.26	1.33	1.40	1.47	1.54	1.61	1.68	1.75	1.82	1.89	1.96	2.03	2.10
6	.72	.78	.84	.90	.96	1.02	1.08	1.14	1.20	1.26	1.32	1.38	1.44	1.50	1.56	1.62	1.68	1.74	1.80
5	.60	.65	.70	.75	.80	.85	.90	.95	1.00	1.05	1.10	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50
4	.48	.52	.56	.60	.64	.68	.72	.76	.80	.84	.88	.92	.96	1.00	1.04	1.08	1.12	1.16	1.20
3	.36	.39	.42	.45	.48	.51	.54	.57	.60	.63	.66	.69	.72	.75	.78	.81	.84	.87	.90
2	.24	.26	.28	.30	.32	.34	.36	.38	.40	.42	.44	.46	.48	.50	.52	.54	.56	.58	.60
1	.12	.13	.14	.15	.16	.17	.18	.19	.20	.21	.22	.23	.24	.25	.26	.27	.28	.29	.30

Table VIII. Pounds of fat in 1 to 1000 lbs. of cream (*continued*).

Cream lbs. \ Test.	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
1000	310	320	330	340	350	360	370	380	390	400	410	420	430	440	450	460	470	480	490	500
900	279	288	297	306	315	324	333	342	351	360	369	378	387	396	405	414	423	432	441	450
800	248	256	264	272	280	288	296	304	312	320	328	336	344	352	360	368	376	384	392	400
700	217	224	231	238	245	252	259	266	273	280	287	294	301	308	315	322	329	336	343	350
600	186	192	198	204	210	216	222	228	234	240	246	252	258	264	270	276	282	288	294	300
500	155	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230	235	240	245	250
400	124	128	132	136	140	144	148	152	156	160	164	168	172	176	180	184	188	192	196	200
300	93	96	99	102	105	108	111	114	117	120	123	126	129	132	135	138	141	144	147	150
200	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100
100	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
90	27.9	28.8	29.7	30.6	31.5	32.4	33.3	34.2	35.1	36.0	36.9	37.8	38.7	39.6	40.5	41.4	42.3	43.2	44.1	45.0
80	24.8	25.6	26.4	27.2	28.0	28.8	29.6	30.4	21.2	32.0	32.8	33.6	34.4	35.2	36.0	36.8	37.6	38.4	39.2	40.0
70	21.7	22.4	23.1	23.8	24.5	25.2	25.9	26.6	27.3	28.0	28.7	29.4	30.1	30.8	31.5	32.2	32.9	33.6	34.3	35.0
60	18.6	19.2	19.8	20.4	21.0	21.6	22.2	22.8	23.4	24.0	24.6	25.2	25.8	26.4	27.0	27.6	28.2	28.8	29.4	30.0
50	15.5	16.0	16.5	17.0	17.5	18.0	18.5	19.0	19.5	20.0	20.5	21.0	21.5	22.0	22.5	23.0	23.5	24.0	24.5	25.0
40	12.4	12.8	13.2	13.6	14.0	14.4	14.8	15.2	15.6	16.0	16.4	16.8	17.2	17.6	18.0	18.4	18.8	19.2	19.6	20.0
30	9.3	9.6	9.9	10.2	10.5	10.8	11.1	11.4	11.7	12.0	12.3	12.6	12.9	13.2	13.5	13.8	14.1	14.4	14.7	15.0
20	6.2	6.4	6.6	6.8	7.0	7.2	7.4	7.6	7.8	8.0	8.2	8.4	8.6	8.8	9.0	9.2	9.4	9.6	9.8	10.0
10	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0
9	2.79	2.88	2.97	3.06	3.15	3.24	3.33	3.42	3.51	3.60	3.69	3.78	3.87	3.96	4.95	4.14	4.23	4.32	4.41	4.50
8	2.48	2.56	2.64	2.72	2.80	2.88	2.96	3.04	3.12	3.20	3.28	3.36	3.44	3.52	3.60	3.68	3.76	3.84	3.92	4.00
7	2.17	2.24	2.31	2.38	2.45	2.52	2.59	2.66	2.73	2.80	2.87	2.94	3.01	3.08	3.15	3.22	3.29	3.36	3.43	3.50
6	1.86	1.92	1.98	2.04	2.10	2.16	2.22	2.28	2.34	2.40	2.46	2.52	2.58	2.64	2.70	2.76	2.82	2.88	2.94	3.00
5	1.55	1.60	1.65	1.70	1.75	1.80	1.85	1.90	1.95	2.00	2.05	2.10	2.15	2.20	2.25	2.30	2.35	2.40	2.45	2.50
4	1.24	1.28	1.32	1.36	1.40	1.44	1.48	1.52	1.56	1.60	1.64	1.68	1.72	1.76	1.80	1.84	1.88	1.92	1.96	2.00
3	.93	.96	.99	1.02	1.05	1.08	1.11	1.14	1.17	1.20	1.23	1.26	1.29	1.32	1.35	1.38	1.41	1.44	1.47	1.50
2	.62	.64	.66	.68	.70	.72	.74	.76	.78	.80	.82	.84	.86	.88	.90	.92	.94	.96	.98	1.00
1	.31	.32	.33	.34	.35	.36	.37	.38	.39	.40	.41	.42	.43	.44	.45	.46	.47	.48	.49	.50

Table IX. Amount due for butter fat, in dollars and cents, at 12 to 25 cents per pound.

(See directions for use, page 266.)

Price per pound, cents.	Pounds of butter fat.										Price per pound, cents.
	1,000	900	800	700	600	500	400	300	200	100	
	$	$	$	$	$	$	$	$	$	$	
12	120.00	108.00	96.00	84.00	72.00	60.00	48.00	36.00	24.00	12.00	12
12¼	122.50	110.25	98.00	85.75	73.50	61.25	49.00	36.75	24.50	12.25	12¼
12½	125.00	112.50	100.00	87.50	75.00	62.50	50.00	37.50	25.00	12.50	12½
12¾	127.50	114.75	102.00	89.25	76.50	63.75	51.00	38.25	25.50	12.75	12¾
13	130.00	117.00	104.00	91.00	78.00	65.00	52.00	39.00	26.00	13.00	13
13¼	132.50	119.25	106.00	92.75	79.50	66.25	53.00	39.75	26.50	13.25	13¼
13½	135.00	121.50	108.00	94.50	81.00	67.50	54.00	40.50	27.00	13.50	13½
13¾	137.50	123.75	110.00	96.25	82.50	68.75	55.00	41.25	27.50	13.75	13¾
14	140.00	126.00	112.00	98.00	84.00	70.00	56.00	42.00	28.00	14.00	14
14¼	142.50	128.25	114.00	99.75	85.50	71.25	57.00	42.75	28.50	14.25	14¼
14½	145.00	130.50	116.00	101.50	87.00	72.50	58.00	43.50	29.00	14.50	14½
14¾	147.50	132.75	118.00	103.25	88.50	73.75	59.00	44.25	29.50	14.75	14¾
15	150.00	135.00	120.00	105.00	90.00	75.00	60.00	45.00	30.00	15.00	15
15¼	152.50	137.25	122.00	106.75	91.50	76.25	61.00	45.75	30.50	15.25	15¼
15½	155.00	139.50	124.00	108.50	93.00	77.50	62.00	46.50	31.00	15.50	15½
15¾	157.50	141.75	126.00	110.25	94.50	78.75	63.00	47.25	31.50	15.75	15¾
16	160.00	144.00	128.00	112.00	96.00	80.00	64.00	48.00	32.00	16.00	16
16¼	162.50	146.25	130.00	113.75	97.50	81.25	65.00	48.75	32.50	16.25	16¼
16½	165.00	148.50	132.00	115.50	99.00	82.50	66.00	49.50	33.00	16.50	16½
16¾	167.50	150.75	134.00	117.25	100.50	83.75	67.00	50.25	33.50	16.75	16¾
17	170.00	153.00	136.00	119.00	102.00	85.00	68.00	51.00	34.00	17.00	17
17¼	172.50	155.25	138.00	120.75	103.50	86.25	69.00	51.75	34.50	17.25	17¼
17½	175.00	157.50	140.00	122.50	105.00	87.50	70.00	52.50	35.00	17.50	17½
17¾	177.50	159.75	142.00	124.25	106.50	87.75	71.00	53.25	35.50	17.75	17¾
18	180.00	162.00	144.00	126.00	108.00	90.00	72.00	54.00	36.00	18.00	18
18¼	182.50	164.25	146.00	127.75	109.50	91.25	73.00	54.75	36.50	18.25	18¼
18½	185.00	166.50	148.00	129.50	111.00	92.50	74.00	55.50	37.00	18.50	18½
18¾	187.50	168.75	150.00	131.25	112.50	93.75	75.00	56.25	37.50	18.75	18¾
	1,000	900	800	700	600	500	400	300	200	100	

Table IX. Amount due for butter fat (*Continued*).

Price per pound, cents.	Pounds of butter fat.										Price per pound, cents.
	1,000	900	800	700	600	500	400	300	200	100	
	$	$	$	$	$	$	$	$	$	$	
19	190.00	171.00	152.00	133.00	114.00	95.00	76.00	57.00	38.00	19.00	19
19¼	192.50	173.25	154.00	134.75	115.50	96.25	77.00	57.75	38.50	19.25	19¼
19½	195.00	175.50	156.00	136.50	117.00	97.50	78.00	58.50	39.00	19.50	19½
19¾	197.50	177.75	158.00	138.25	118.50	98.75	79.00	59.25	39.50	19.75	19¾
20	200.00	180.00	160.00	140.00	120.00	100.00	80.00	60.00	40.00	20.00	20
20¼	202.50	182.25	162.00	141.75	121.50	101.25	81.00	60.75	40.50	20.25	20¼
20½	205.00	184.50	164.00	143.50	123.00	102.50	82.00	61.50	41.00	20.50	20½
20¾	207.50	186.75	166.00	145.25	124.50	103.75	83.00	62.25	41.50	20.75	20¾
21	210.00	189.00	168.00	147.00	126.00	105.00	84.00	63.00	42.00	21.00	21
21¼	212.50	191.25	170.00	148.75	127.50	106.25	85.00	63.75	42.50	21.25	21¼
21½	215.00	193.50	172.00	150.50	129.00	107.50	86.00	64.50	43.00	21.50	21½
21¾	217.50	195.75	174.00	152.25	130.50	108.75	87.00	65.25	43.50	21.75	21¾
22	220.00	198.00	176.00	154.00	132.00	110.00	88.00	66.00	44.00	22.00	22
22¼	222.50	200.25	178.00	155.75	133.50	111.25	89.00	66.75	44.50	22.25	22¼
22½	225.00	202.50	180.00	157.50	135.00	112.50	90.00	67.50	45.00	22.50	22½
22¾	227.50	204.75	182.00	159.25	136.50	113.75	91.00	68.25	45.50	22.75	22¾
23	230.00	207.00	184.00	161.00	138.00	115.00	92.00	69.00	46.00	23.00	23
23¼	232.50	209.25	186.00	162.75	139.50	116.25	93.00	69.75	46.50	23.25	23¼
23½	235.00	211.50	188.00	164.50	141.00	117.50	94.00	70.50	47.00	23.50	23½
23¾	237.50	213.75	190.00	166.25	142.50	118.75	95.00	71.25	47.50	23.75	23¾
24	240.00	216.00	192.00	168.00	144.00	120.00	96.00	72.00	48.00	24.00	24
24¼	242.50	218.25	194.00	169.75	145.50	121.25	97.00	72.75	48.50	24.25	24¼
24½	245.00	220.50	196.00	171.50	147.00	122.50	98.00	73.50	49.00	24.50	24½
24¾	247.50	222.75	198.00	173.25	148.50	123.75	99.00	74.25	49.50	24.75	24¾
25	250.00	225.00	200.00	175.00	150.00	125.00	100.00	75.00	50.00	25.00	25
	1,000	900	800	700	600	500	400	300	200	100	

Table X. Relative-value tables.

(See directions for use, par. 238.)

Per cent. fat.	Price of milk per 100 pounds, in dollars and cents.										
3.0	.30	.31	.33	.34	.36	.37	.39	.40	.42	.43	.45
3.1	.31	.33	.34	.36	.37	.39	.40	.42	.43	.45	.46
3.2	.32	.34	.35	.37	.38	.40	.42	.43	.45	.46	.48
3.3	.33	.35	.36	.38	.40	.41	.43	.45	.46	.48	.49
3.4	.34	.36	.37	.39	.41	.42	.44	.46	.48	.49	.51
3.5	.35	.37	.38	.40	.42	.44	.45	.47	.49	.51	.52
3.6	.36	.38	.40	.41	.43	.45	.47	.49	.50	.52	.54
3.7	.37	.39	.41	.43	.44	.46	.48	.50	.52	.54	.55
3.8	.38	.40	.42	.44	.46	.47	.49	.51	.53	.55	.57
3.9	.39	.41	.43	.45	.47	.49	.51	.53	.55	.57	.58
4.0	.40	.42	.44	.46	.48	.50	.52	.54	.56	.58	.60
4.1	.41	.43	.45	.47	.49	.51	.53	.55	.57	.59	.61
4.2	.42	.44	.46	.48	.50	.52	.55	.57	.59	.61	.63
4.3	.43	.45	.47	.49	.52	.54	.56	.58	.60	.62	.64
4.4	.44	.46	.48	.51	.53	.55	.57	.59	.62	.64	.66
4.5	.45	.47	.49	.52	.54	.56	.58	.61	.63	.65	.67
4.6	.46	.48	.51	.53	.55	.57	.60	.62	.64	.67	.69
4.7	.47	.49	.52	.54	.56	.59	.61	.63	.66	.68	.70
4.8	.48	.50	.53	.55	58	.60	.62	.65	.67	.70	.72
4.9	.49	.51	.54	.56	.59	.61	.64	.66	.69	.71	.73
5.0	.50	.52	.55	.57	.60	.62	.65	.67	.70	.72	.75
5.1	.51	.54	.56	.59	.61	.64	.66	.69	.71	.74	.76
5.2	.52	.55	.57	.60	.62	.65	.68	.70	.73	.75	.78
5.3	.53	.56	.58	.61	.64	.66	.69	.72	.74	.77	.79
5.4	.54	.57	.59	.62	.65	.67	.70	.73	.76	.78	.81
5.5	.55	.58	.60	.63	.66	.69	.71	.74	.77	.80	.82
5.6	.56	.59	.62	.64	.67	.70	.73	.76	.78	.81	.84
5.7	.57	.60	.63	.66	.68	.71	.74	.77	.80	.83	.85
5.8	.58	.61	.64	.67	.70	.72	.75	.78	.81	.84	.87
5.9	.59	.62	.65	.68	.71	.74	.77	.80	.83	.86	.88
6.0	.60	.63	.66	.69	.72	.75	.78	.81	.84	.87	.90

Table X. Relative-value tables (*Continued*).

Per cent. fat.	Price of milk per 100 pounds, in dollars and cents.									
3.0	.46	.48	.49	.51	.52	.54	.55	.57	.58	.60
3.1	.48	.50	.51	.53	.54	.56	.57	.59	.60	.62
3.2	.50	.51	.53	.54	.56	.58	.59	.61	.62	.64
3.3	.51	.53	.54	.56	.58	.59	.61	.63	.64	.66
3.4	.53	.54	.56	.58	.59	.61	.63	.65	.66	.68
3.5	.54	.56	.58	.59	.61	.63	.65	.66	.68	.70
3.6	.56	.58	.59	.61	.63	.65	.67	.68	.70	.72
3.7	.57	.59	.61	.63	.65	.67	.68	.70	.72	.74
3.8	.59	.61	.63	.65	.66	.68	.70	.72	.74	.76
3.9	.60	.62	.64	.66	.68	.70	.72	.74	.76	.78
4.0	.62	.64	.66	.68	.70	.72	.74	.76	.78	.80
4.1	.64	.66	.68	.70	.72	.74	.76	.78	.80	.82
4.2	.65	.67	.69	.71	.73	.76	.78	.80	.82	.84
4.3	.67	.69	.71	.73	.75	.77	.80	.82	.84	.86
4.4	.68	.70	.73	.75	.77	.79	.81	.84	.86	.88
4.5	.70	.72	.74	.76	.79	.81	.83	.85	.88	.90
4.6	.71	.74	.76	.78	.80	.83	.85	.87	.90	.92
4.7	.73	.75	.78	.80	.82	.85	.87	.89	.92	.94
4.8	.74	.77	.79	.82	.84	.86	.89	.91	.94	.96
4.9	.76	.78	.81	.83	.86	.88	.91	.93	.96	.98
5.0	.77	.80	.82	.85	.87	.90	.92	.95	.97	1.00
5.1	.79	.82	.84	.87	.89	.92	.94	.97	.99	1.02
5.2	.81	.83	.86	.88	.91	.94	.96	.99	1.01	1.04
5.3	.83	.85	.87	.90	.93	.95	.98	1.01	1.03	1.06
5.4	.84	.86	.89	.92	.94	.97	1.00	1.03	1.05	1.08
5.5	.85	.88	.91	.93	.96	.99	1.02	1.04	1.07	1.10
5.6	.87	.90	.92	.95	.98	1.01	1.04	1.06	1.09	1.12
5.7	.88	.91	.94	.97	1.00	1.03	1.05	1.08	1.11	1.14
5.8	.90	.93	.96	.99	1.01	1.04	1.07	1.10	1.13	1.16
5.9	.91	.94	.97	1.00	1.03	1.06	1.09	1.12	1.15	1.18
6.0	.93	.96	.99	1.02	1.05	1.08	1.11	1.14	1.17	1.20

Table X. Relative-value tables (*Continued*).

Per cent. fat.	Price of milk per 100 pounds, in dollars and cents.									
3.0	.61	.63	.64	.66	.67	.69	.70	.72	.73	.75
3.1	.64	.65	.67	.68	.70	.71	.73	.74	.76	.78
3.2	.66	.67	.69	.70	.72	.74	.75	.77	.78	.80
3.3	.68	.69	.71	.73	.74	.76	.78	.79	.81	.83
3.4	.70	.71	.73	.75	.76	.78	.80	.82	.83	.85
3.5	.72	.73	.75	.77	.79	.80	.82	.84	.86	.88
3.6	.74	.76	.77	.79	.81	.83	.85	.86	.88	.90
3.7	.76	.78	.80	.81	.83	.85	.87	.89	.91	.93
3.8	.78	.80	.82	.84	.85	.87	.89	.91	.93	.95
3.9	.80	.82	.84	.86	.88	.90	.92	.94	.96	.98
4.0	.82	.84	.86	.88	.90	.92	.94	.96	.98	1.00
4.1	.84	.86	.88	.90	.92	.94	.96	.98	1.00	1.03
4.2	.86	.88	.90	.92	.94	.97	.99	1.01	1.03	1.05
4.3	.88	.90	.92	.95	.97	.99	1.01	1.03	1.05	1.08
4.4	.90	.92	.95	.97	.99	1.01	1.03	1.06	1.08	1.10
4.5	.92	.94	.97	.99	1.01	1.03	1.06	1.08	1.10	1.13
4.6	.94	.97	.99	1.01	1.03	1.06	1.08	1.10	1.13	1.15
4.7	.96	.99	1.01	1.03	1.06	1.08	1.10	1.13	1.15	1.18
4.8	.98	1.01	1.03	1.06	1.08	1.10	1.13	1.15	1.18	1.20
4.9	1.00	1.03	1.05	1.08	1.10	1.13	1.15	1.18	1.20	1.23
5.0	1.02	1.05	1.07	1.10	1.12	1.15	1.18	1.20	1.23	1.25
5.1	1.05	1.07	1.10	1.12	1.15	1.17	1.20	1.22	1.25	1.27
5.2	1.07	1.09	1.12	1.14	1.17	1.20	1.22	1.25	1.27	1.30
5.3	1.09	1.11	1.14	1.17	1.19	1.22	1.25	1.27	1.30	1.32
5.4	1.11	1.13	1.16	1.19	1.21	1.24	1.27	1.30	1.32	1.35
5.5	1.13	1.15	1.18	1.21	1.24	1.26	1.29	1.32	1.35	1.38
5.6	1.15	1.18	1.20	1.23	1.26	1.29	1.32	1.34	1.37	1.40
5.7	1.17	1.20	1.23	1.25	1.28	1.31	1.34	1.37	1.39	1.43
5.8	1.19	1.22	1.25	1.28	1.30	1.33	1.36	1.39	1.42	1.45
5.9	1.21	1.24	1.27	1.30	1.33	1.36	1.39	1.42	1.45	1.48
6.0	1.23	1.26	1.29	1.32	1.35	1.38	1.41	1.44	1.47	1.50

Table X. Relative-value tables (*Continued*).

Per cent. fat.	Price of milk per 100 pounds, in dollars and cents.									
3.0	.76	.78	.79	.81	.82	.84	.85	.87	.88	.90
3.1	.79	.81	.82	.84	.85	.87	.88	.90	.91	.93
3.2	.82	.83	.85	.86	.88	.90	.91	.93	.94	.96
3.3	.84	.86	.87	.89	.91	.92	.94	.96	.97	.99
3.4	.87	.88	.90	.92	.93	.95	.97	.99	1.00	1.02
3.5	.89	.91	.93	.94	.96	.98	1.00	1.01	1.03	1.05
3.6	.92	.94	.95	.97	.99	1.00	1.03	1.04	1.06	1.08
3.7	.94	.96	.98	1.00	1.02	1.03	1.05	1.07	1.09	1.11
3.8	.97	.99	1.01	1.03	1.04	1.06	1.08	1.10	1.12	1.14
3.9	.99	1.01	1.03	1.05	1.07	1.09	1.11	1.13	1.15	1.17
4.0	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.20
4.1	1.05	1.07	1.09	1.11	1.13	1.15	1.17	1.19	1.21	1.23
4.2	1.07	1.09	1.11	1.13	1.15	1.18	1.20	1.22	1.24	1.26
4.3	1.10	1.12	1.14	1.16	1.18	1.20	1.23	1.25	1.27	1.29
4.4	1.12	1.14	1.17	1.19	1.21	1.23	1.25	1.28	1.30	1.32
4.5	1.15	1.17	1.19	1.21	1.24	1.26	1.28	1.30	1.33	1.35
4.6	1.17	1.20	1.22	1.24	1.26	1.29	1.31	1.33	1.36	1.38
4.7	1.20	1.22	1.25	1.27	1.29	1.32	1.34	1.36	1.39	1.41
4.8	1.22	1.25	1.27	1.30	1.32	1.34	1.37	1.39	1.42	1.44
4.9	1.25	1.27	1.30	1.32	1.35	1.37	1.40	1.42	1.45	1.47
5.0	1.27	1.30	1.32	1.35	1.37	1.40	1.42	1.45	1.47	1.50
5.1	1.30	1.33	1.35	1.38	1.40	1.43	1.45	1.48	1.50	1.53
5.2	1.33	1.35	1.37	1.40	1.43	1.46	1.48	1.51	1.53	1.56
5.3	1.35	1.38	1.40	1.43	1.46	1.48	1.51	1.54	1.56	1.59
5.4	1.38	1.40	1.43	1.46	1.48	1.51	1.54	1.57	1.59	1.62
5.5	1.40	1.43	1.46	1.48	1.51	1.54	1.57	1.60	1.62	1.65
5.6	1.43	1.46	1.48	1.51	1.54	1.57	1.60	1.62	1.65	1.68
5.7	1.45	1.48	1.51	1.54	1.57	1.60	1.62	1.65	1.68	1.71
5.8	1.48	1.51	1.54	1.57	1.59	1.62	1.65	1.68	1.71	1.74
5.9	1.50	1.53	1.56	1.59	1.62	1.65	1.68	1.71	1.74	1.77
6.0	1.53	1.56	1.59	1.62	1.65	1.68	1.71	1.74	1.77	1.80

Table XI. Butter chart, showing calculated yield of butter (in lbs.) from 1 to 10,000 lbs. of milk, testing 3.0 to 5.3 per cent. (See directions for use, p. 266.)

Test.	3.00	3.10	3.20	3.30	3.40	3.50	3.60	3.70	3.80	3.90	4.00	4.10	Test.
Milk, lbs.													Milk, lbs.
10,000	325	336	348	360	371	383	394	406	418	429	441	452	10,000
9,000	293	302	313	324	334	345	355	365	376	386	397	407	9,000
8,000	260	269	278	288	297	306	315	325	334	343	353	362	8,000
7,000	228	235	244	252	260	268	276	284	293	300	309	316	7,000
6,000	195	202	209	216	223	230	236	244	251	257	265	271	6,000
5,000	163	168	174	180	186	192	197	203	209	215	221	226	5,000
4,000	130	134	139	144	148	153	158	162	167	172	176	181	4,000
3,000	97.5	101	104	108	111	115	118	122	125	129	132	136	3,000
2,000	65.0	67.2	69.6	72.0	74.2	76.6	78.8	81.2	83.6	85.8	88.2	90.4	2,000
1,000	32.5	33.6	34.8	36.0	37.1	38.3	39.4	40.6	41.8	43.9	44.1	45.2	1,000
900	29.3	30.2	31.3	32.4	33.4	34.5	35.5	36.5	37.6	38.6	39.7	40.7	900
800	26.0	26.9	27.8	28.8	29.7	30.6	31.5	32.5	33.4	34.3	35.3	36.2	800
700	22.8	23.5	24.4	25.2	26.0	26.8	27.6	28.4	29.3	30.0	30.9	31.6	700
600	19.5	20.2	20.9	21.6	22.3	23.0	23.6	24.4	25.1	25.7	26.5	27.1	600
500	16.3	16.8	17.4	18.0	18.6	19.2	19.7	20.3	20.9	21.5	22.1	22.6	500
400	13.0	13.4	13.9	14.4	14.8	15.3	15.8	16.2	16.7	17.2	17.6	18.1	400
300	9.7	10.1	10.4	10.8	11.1	11.5	11.8	12.2	12.5	12.9	13.2	13.6	300
200	6.5	6.7	6.9	7.2	7.4	7.6	7.9	8.1	8.3	8.6	8.8	9.0	200
100	3.2	3.4	3.5	3.6	3.7	3.8	3.9	4.1	4.2	4.3	4.4	4.5	100
90	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.1	90
80	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.4	3.5	3.6	80
70	2.3	2.3	2.4	2.5	2.6	2.7	2.8	2.8	2.9	3.0	3.1	3.2	70
60	1.9	2.0	2.1	2.2	2.2	2.3	2.4	2.4	2.5	2.6	2.7	2.7	60
50	1.6	1.7	1.7	1.8	1.9	1.9	2.0	2.0	2.1	2.2	2.2	2.3	50
40	1.3	1.3	1.4	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.8	1.8	40
30	1.0	1.0	1.0	1.1	1.1	1.2	1.2	1.2	1.3	1.3	1.3	1.4	30
20	.6	.7	.7	.7	.7	.8	.8	.8	.8	.9	.9	.9	20
10	.3	.3	.4	.4	.4	.4	.4	.4	.4	.4	.4	.5	10
9	.3	.3	.3	.3	.3	.3	.4	.4	.4	.4	.4	.4	9
8	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.4	.4	8
7	.2	.2	.2	.3	.3	.3	.3	.3	.3	.3	.3	.3	7
6	.2	.2	.2	.2	.2	.2	.2	.2	.3	.3	.3	.3	6
5	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	5
4	.1	.1	.1	.2	.2	.2	.2	.2	.2	.2	.2	.2	4
3	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	3
2	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	2
1													1
Test.	3.00	3.10	3.20	3.30	3.40	3.50	3.60	3.70	3.80	3.90	4.00	4.10	Test.

Table XI. Butter chart (*Continued*).

Test.	4.20	4.30	4.40	4.50	4.60	4.70	4.80	4.90	5.00	5.10	5.20	5.30	Test.
Milk lbs.													Milk lbs.
10,000	464	476	487	499	510	522	534	545	557	568	580	592	10,000
9,000	418	428	438	449	459	470	481	491	501	511	522	533	9,000
8,000	371	381	390	399	408	418	427	436	446	454	464	474	8,000
7,000	325	333	341	349	357	365	374	382	390	398	406	414	7,000
6,000	278	286	292	299	306	313	320	327	334	341	348	355	6,000
5,000	232	238	244	250	255	261	267	273	279	284	290	296	5,000
4,000	186	190	195	200	204	209	214	218	223	227	232	237	4,000
3,000	139	143	146	150	153	157	160	164	167	170	174	178	3,000
2,000	92.8	95.2	97.4	99.8	102	104	107	109	111	114	116	118	2,000
1,000	46.4	47.6	48.7	49.9	51.0	52.2	53.4	54.5	55.7	56.8	58.0	59.2	1,000
900	41.8	42.8	43.8	44.9	45.9	47.0	48.1	49.1	50.1	51.1	52.2	53.3	900
800	37.1	38.1	39.0	39.9	40.8	41.8	42.7	43.6	44.6	45.4	46.4	47.4	800
700	32.5	33.3	34.1	34.9	35.7	36.5	37.4	38.2	39.0	39.8	40.6	41.4	700
600	27.8	28.6	29.2	29.9	30.6	31.3	32.0	32.7	33.4	34.1	34.8	35.5	600
500	23.2	23.8	24.4	25.0	25.5	26.1	26.7	27.3	27.9	28.4	29.0	29.6	500
400	18.6	19.0	19.5	20.0	20.4	20.9	21.4	21.8	22.3	22.7	23.2	23.7	400
300	13.9	14.3	14.6	15.0	15.3	15.7	16.0	16.4	16.7	17.0	17.4	17.8	300
200	9.3	9.5	9.7	10.0	10.2	10.4	10.7	10.9	11.1	11.4	11.6	11.8	200
100	4.6	4.8	4.9	5.0	5.1	5.2	5.3	5.5	5.6	5.7	5.8	5.9	100
90	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0	5.1	5.2	5.3	90
80	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.5	4.6	4.7	80
70	3.3	3.3	3.4	3.5	3.6	3.7	3.7	3.8	3.9	4.0	4.1	4.1	70
60	2.8	2.9	2.9	3.0	3.1	3.1	3.2	3.3	3.3	3.4	3.5	3.6	60
50	2.3	2.4	2.4	2.5	2.6	2.6	2.7	2.7	2.8	2.8	2.9	3.0	50
40	1.9	1.9	2.0	2.0	2.0	2.1	2.1	2.2	2.2	2.3	2.3	2.4	40
30	1.4	1.4	1.5	1.5	1.5	1.6	1.6	1.6	1.7	1.7	1.7	1.8	30
20	.9	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1 1	1.1	1.2	1.2	20
10	.5	.5	.5	.5	.5	.5	.5	.6	.6	.6	.6	.6	10
9	.4	.4	.4	.5	.5	.5	.5	.5	.5	.5	.5	.5	9
8	.4	.4	.4	.4	.4	.4	.4	.4	.5	.5	.5	.5	8
7	.3	.3	.3	.4	.4	.4	.4	.4	.4	.4	.4	.4	7
6	.3	.3	.3	.3	.3	.3	.3	.3	.3	.3	.4	.4	6
5	.2	.2	.2	.3	.3	.3	.3	.3	.3	.3	.3	.3	5
4	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	4
3	.1	.1	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	3
2	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	2
1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	1
Test.	4.20	4.30	4.40	4.50	4.60	4.70	4.80	4.90	5.00	5.10	5.20	5.30	Test.

Table XII. Overrun table, showing pounds of butter from one hundred lbs. of milk. (See directions for use, par. 222.)

Per cent. fat.	1.10	1.11	1.12	1.13	1.14	1.15	1.16	1.17	1.18	1.19	1.20	Per cent. fat.
3.0	3.30	3.33	3.36	3.39	3.42	3.45	3.48	3.51	3.54	3.57	3.60	3.0
3.1	3.41	3.44	3.47	3.50	3.53	3.57	3.60	3.63	3.66	3.68	3.72	3.1
3.2	3.52	3.55	3.58	3.62	3.65	3.68	3.71	3.74	3.78	3.81	3.84	3.2
3.3	3.63	3.66	3.70	3.73	3.76	3.80	3.83	3.86	3.89	3.93	3.96	3.3
3.4	3.74	3.77	3.81	3.84	3.88	3.91	3.94	3.98	4.01	4.05	4.08	3.4
3.5	3.85	3.89	3.92	3.96	3.99	4.03	4.06	4.10	4.13	4.17	4.20	3.5
3.6	3.96	4.00	4.03	4.07	4.10	4.14	4.18	4.21	4.25	4.28	4.32	3.6
3.7	4.07	4.11	4.14	4.18	4.22	4.26	4.29	4.33	4.37	4.40	4.44	3.7
3.8	4.18	4.22	4.26	4.29	4.33	4.37	4.41	4.45	4.48	4.52	4.56	3.8
3.9	4.29	4.33	4.37	4.41	4.45	4.49	4.52	4.56	4.60	4.64	4.68	3.9
4.0	4.40	4.44	4.48	4.52	4.56	4.60	4.64	4.68	4.72	4.76	4.80	4.0
4.1	4.51	4.55	4.59	4.63	4.67	4.72	4.76	4.80	4.84	4.88	4.92	4.1
4.2	4.62	4.66	4.70	4.75	4.79	4.83	4.87	4.91	4.96	5.00	5.04	4.2
4.3	4.73	4.77	4.82	4.86	4.90	4.95	4.99	5.03	5.07	5.12	5.16	4.3
4.4	4.84	4.88	4.93	4.97	5.02	5.06	5.10	5.15	5.19	5.24	5.28	4.4
4.5	4.95	5.00	5.04	5.09	5.13	5.18	5.22	5.27	5.31	5.36	5.40	4.5
4.6	5.06	5.11	5.15	5.20	5.24	5.29	5.34	5.38	5.43	5.47	5.52	4.6
4.7	5.17	5.22	5.26	5.31	5.36	5.41	5.45	5.49	5.55	5.59	5.64	4.7
4.8	5.28	5.33	5.38	5.42	5.47	5.52	5.57	5.62	5.66	5.71	5.76	4.8
4.9	5.39	5.44	5.49	5.54	5.59	5.64	5.68	5.73	5.78	5.83	5.88	4.9
5.0	5.50	5 55	5.60	5.65	5.70	5.75	5.80	5.85	5.90	5.95	6.00	5.0
5.1	5.61	5.66	5.71	5.76	5.81	5.87	5.92	5.97	6.02	6.07	6.12	5.1
5.2	5.72	5.77	5.82	5.88	5.93	5.98	6.03	6.08	6.14	6.19	6.24	5.2
5.3	5.83	5.88	5.94	5.99	6.04	6.10	6.15	6.20	6.25	6.31	6.36	5.3
5.4	5.94	5.99	6.05	6.10	6.16	6.21	6.26	6.32	6.37	6.43	6.48	5.4
5.5	6.05	6.11	6.16	6.22	6.27	6.33	6.38	6.44	6.49	6.55	6.60	5.5
5.6	6.16	6.22	6.27	6.33	6.38	6.44	6.50	6.55	6.61	6.66	6.72	5.6
5.7	6.27	6.33	6.38	6.44	6.50	6.56	6.61	6.67	6.73	6.78	6.84	5.7
5.8	6.38	6.44	6.50	6.55	6.61	6.67	6.73	6.79	6.84	6.90	6.96	5.8
5.9	6.49	6.55	6.61	6.67	6.73	6.79	6.84	6.90	6.96	7.02	7.08	5.9
6.0	6.60	6.66	6.72	6.78	6.84	6.90	6.96	7.02	7.08	7.14	7.20	6.0

Table XIII. Yield of Cheese from 100 lbs. milk with 2.5 to 6 per cent. of fat, and lacometer readings from 26 to 30.
(See par. 224)

Per cent. of fat.	Lactometer degrees.											Per cent. of fat.
	26	27	28	29	30	31	32	33	34	35	36	
2.5	7.28	7.41	7.54	7.67	7.81	7.94	8.07	8.20	8.33	8.47	8.60	2.5
2.6	7.44	7.57	7.70	7.83	7.96	8.09	8.22	8.35	8.49	8.62	8.76	2.6
2.7	7.59	7.72	7.85	7.99	8.12	8.25	8.38	8.51	8.64	8.77	8.91	2.7
2.8	7.74	7.87	8.00	8.14	8.27	8.40	8.53	8.67	8.80	8.94	9.07	2.8
2.9	7.90	8.03	8.16	8.30	8.44	8.56	8.69	8.82	8.95	9.09	9.22	2.9
3.0	8.05	8.18	8.31	8.45	8.58	8.71	8.84	8.97	9.11	9.24	9.37	3.0
3.1	8.21	8.34	8.47	8.60	8.74	8.87	9.00	9.13	9.26	9.39	9.53	3.1
3.2	8.36	8.49	8.62	8.75	8.89	9.02	9.15	9.28	9.42	9.55	9.68	3.2
3.3	8.52	8.65	8.78	8.91	9.05	9.18	9.31	9.44	9.57	9.70	9.84	3.3
3.4	8.67	8.80	8.93	9.06	9.20	9.33	9.46	9.59	9.73	9.86	9.99	3.4
3.5	8.82	8.96	9.09	9.22	9.35	9.48	9.62	9.75	9.88	10.01	10.15	3.5
3.6	8.98	9.11	9.24	9.37	9.50	9.63	9.77	9.90	10.03	10.17	10.30	3.6
3.7	9.13	9.26	9.39	9.52	9.65	9.78	9.92	10.05	10.19	10.32	10.46	3.7
3.8	9.29	9.42	9.55	9.68	9.81	9.94	10.08	10.21	10.34	10.48	10.61	3.8
3.9	9.44	9.57	9.70	9.84	9.97	10.10	10.23	10.36	10.50	10.64	10.77	3.9
4.0	9.60	9.73	9.86	10.00	10.13	10.26	10.39	10.53	10.66	10.79	10.93	4.0
4.1	9.75	9.88	10.02	10.15	10.28	10.89	10.54	10.68	10.81	10.94	11.08	4.1
4.2	9.90	10.03	10.17	10.30	10.43	10.57	10.70	10.84	10.97	11.10	11.24	4.2
4.3	10.06	10.19	10.32	10.45	10.58	10.72	10.85	10.99	11.12	11.25	11.39	4.3
4.4	10.21	10.34	10.48	10.61	10.74	10.87	11.00	11.14	11.27	11.41	11.55	4.4
4.5	10.36	10.49	10.63	10.76	10.89	11.03	11.16	11.29	11.42	11.56	11.70	4.5
4.6	10.52	10.65	10.78	10.92	11.05	11.18	11.31	11.45	11.58	11.71	11.85	4.6
4.7	10.67	10.81	10.94	11.07	11.20	11.34	11.47	11.60	11.73	11.87	12.01	4.7
4.8	10.83	10.96	11.09	11.22	11.36	11.49	11.62	11.76	11.89	12.02	12.16	4.8
4.9	10.98	11.11	11.25	11.38	11.51	11.65	11.78	11.91	12.04	12.18	12.32	4.9
5.0	11.14	11.27	11.40	11.54	11.67	11.80	11.93	12.07	12.20	12.34	12.48	5.0
5.1	11.29	11.42	11.55	11.69	11.82	11.96	12.09	12.23	12.36	12.49	12.63	5.1
5.2	11.45	11.58	11.71	11.85	11.98	12.11	12.24	12.38	12.52	12.66	12.80	5.2
5.3	11.60	11.73	11.86	11.99	12.13	12.27	12.40	12.53	12.67	12.71	12.85	5.3
5.4	11.76	11.89	12.02	12.16	12.29	12.42	12.55	12.69	12.83	12.97	13.01	5.4
5.5	11.91	12.04	12.17	12.31	12.44	12.58	12.71	12.85	12.99	13.12	13.25	5.5
5.6	12.07	12.20	12.33	12.47	12.60	12.73	12.87	13.00	13.14	13.28	13.41	5.6
5.7	12.22	12.35	12.48	12.62	12.75	12.89	13.02	13.16	13.30	13.44	13.57	5.7
5.8	12.38	12.51	12.64	12.77	12.91	13.05	13.18	13.31	13.45	13.59	13.72	5.8
5.9	12.53	12.66	12.79	12.93	13.06	13.19	13.33	13.47	13.60	13.74	13.87	5.9
6.0	12.69	12.82	12.95	13.09	13.22	13.35	13.49	13.62	13.75	13.89	14.02	6.0

Table XIV. Comparisons of Fahrenheit and Centigrade (Celsius) thermometer scales.

Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.
+212	+100	+176	+80	+140	+60
211	99.44	175	79.44	139	59.44
210	98.89	174	78.89	138	58.89
209	98.33	173	78.33	137	58.33
208	97.78	172	77.78	136	57.78
207	97.22	171	77.22	135	57.22
206	96.67	170	76.67	134	56.67
205	96.11	169	76.11	133	56.11
204	95.55	168	75.55	132	55.55
203	95	167	75	131	55
202	94.44	166	74.44	130	54.44
201	93.89	165	73.89	129	53.89
200	93.33	164	72.33	128	53.33
199	92.78	163	72.78	127	52.78
198	92.22	162	71.22	126	52.22
197	91.67	161	71.67	125	51.67
196	91.11	160	71.11	124	51.11
195	90.55	159	70.55	123	50.55
194	90	158	70	122	50
193	89.44	157	69.44	121	49.44
192	88.89	156	68.89	120	48.89
191	88.33	155	68.33	119	48.33
190	87.78	154	67.78	118	47.78
189	87.22	153	67.22	117	47.22
188	86.67	152	66.67	116	46.67
187	86.11	151	66.11	115	46.11
186	85.55	150	65.55	114	45.55
185	85	149	65	113	45
184	84.44	148	64.44	112	44.44
183	83.89	147	63.89	111	43.89
182	83.33	146	63.33	110	43.33
181	82.78	145	62.78	109	42.78
180	82.22	144	62.22	108	42.22
179	81.67	143	61.67	107	41.67
178	81.11	142	61.11	106	41.11
177	80.55	141	60.55	105	40.55

Table XIV. Comparisons of thermometer scales (*Continued.*)

Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.	Fahrenheit.	Centigrade.
+104	+40	+68	+20	+32	+0
103	39.44	67	19.44	31	—0.55
102	38.89	66	18.89	30	1.11
101	38.33	65	18.33	29	1.67
100	37.78	64	17.78	28	2.22
99	37.22	63	17.22	27	2.78
98	36.67	62	16.67	26	3.33
97	36.11	61	16.11	25	3.89
96	35.55	60	15.55	24	4.44
95	35	59	15	23	5
94	34.44	58	14.44	22	5.55
93	33.89	57	13.89	21	6.11
92	33.33	56	13.33	20	6.67
91	32.78	55	12.78	19	7.22
90	32 22	54	12.22	18	7.78
89	31.67	53	11.67	17	8.33
88	31.11	52	11.11	16	8.89
87	30.55	51	10.55	15	9.44
86	30	50	10	14	10
85	29.44	49	9.44	13	10.55
84	28.89	48	8.89	12	11.11
83	28.33	47	8.33	11	11.67
82	27.78	46	7.78	10	12.22
81	27.22	45	7.22	9	12.78
80	26.67	44	6.67	8	13.33
79	26.11	43	6.11	7	13.89
78	25.55	42	5.55	6	14.44
77	25	41	5	5	15.00
76	24.44	40	4.44	4	15.55
75	23.89	39	3.89	3	16.11
74	23.33	38	3.33	2	16.67
73	22.78	37	2.78	1	17.22
72	22.22	36	2.22	0	17.78
71	21.67	35	1.67	—1	18.33
70	21.11	34	1.11	2	18.89
69	20.55	33	0.55	3	19.44

To convert deg. Fahrenheit to corresponding deg. Centigrade: Subtract 32, multiply difference by 5, and divide by 9.

Example: Which degree Centigrade corresponds to 110° F.? 110 − 32 = 78; 78 × 5 = 390; 390 ÷ 9 = 43.33.

To convert deg. Centigrade to corresponding deg. Fahrenheit: Multiply by 9, divide product by 5, and add 32 to quotient.

Example: Which degree Fahrenheit corresponds to 95.5° C.? 95.5 × 9 = 859.5; 859.5 ÷ 5 = 171.9; 171.9 + 32 = 203.6.

Table XV. Comparison of metric and customary weights and measures.

Customary weights and measures.	Equivalents in metric system.	Metric weights and measures.	Equivalents in customary system.
1 inch	2.54 centimeters.	1 meter	39.37 inches.
1 foot	.3048 meter.	1 meter	1.0936 yards.
1 mile	1.6094 kilometers.	1 kilometer	.6214 mile.
1 square inch	6.452 sq. centimeters.	1 sq. centimeter	.155 sq. inch.
1 square foot	9.29 sq. decimeters.	1 square meter	10.764 sq. feet.
1 square yard.	.836 sq. meter.	1 square meter	1.196 sq. yards.
1 acre	.4047 hectare.	1 hectare	2.471 acres.
1 cubic inch	16.387 cc.	1 cc	.061 cubic inch.
1 cubic foot	.0283 cub. meter.	1 cub. decimeter	61.023 cubic inches.
1 cubic yard	.765 cub. meter	1 cub. meter	35.314 cub. feet.
1 bushel	.3552 hectoliter	1 hectoliter	2.8377 bushels.
1 fluid ounce	29.57 cc.	1 cc	.0338 fluid ounce.
1 quart	.9464 liter.	1 liter	1.0567 quarts.
1 gallon	3.7854 liters.	1 decaliter	2.6417 quarts.
1 grain	64.8 milligrams.	1 gram	15.43 grains.
1 ounce (av.)	28.35 grams.	1 gram	.035274 ounce.
1 pound (av.)	.4536 kilogram.	1 kilogram	2.2046 pounds (av.

Table XVI. Specific Gravity and Weight of one Gallon of Cream, in Pounds, arranged according to the per cent. of fat.

Per cent of fat in cream	*Specific gravity of cream*	*Weight of one gallon lbs.*	*Per cent of fat in cream*	*Specific gravity of cream*	*Weight of one gallon lbs.*
0	1.036	8.6391	35	0.9963	8.3076
10	1.0243	8.5417	36	0.9952	8.2985
15	1.0186	8.4938	37	0.9941	8.2894
16	1.0174	8.4843	38	0.9930	8.2804
17	1.0163	8.4749	39	0.9919	8.2714
18	1.0152	8.4654	40	0.9908	8.2624
19	1.0140	8.4560	41	0.9897	8.2534
20	1.0129	8.4465	42	0.9886	8.2444
21	1.0118	8.4372	43	0.9875	8.2354
22	1.0107	8.4278	44	0.9864	8.2265
23	1.0096	8.4184	45	0.9854	8.2176
24	1.0085	8.4090	46	0.9843	8.2087
25	1.0073	8.3997	47	0.9832	8.1998
26	1.0062	8.3905	48	0.9821	8.1909
27	1.0051	8.3812	49	0.9811	8.1821
28	1.0040	8.3719	50	0.9801	8.1733
29	1.0029	8.3626	51	0.9790	8.1646
30	1.0017	8.3534	52	0.9780	8.1558
31	1.0006	8.3443	53	0.9770	8.1470
32	0.9995	8.3352	54	0.9760	8.1382
33	0.9984	8.3260	55	0.9749	8.1294
34	0.9973	8.3168			

SUGGESTIONS regarding the organization of co-operative creameries and cheese factories.

When the farmers of a neighborhood are considering the establishment of a creamery or cheese factory, they should first of all make an accurate canvas of the locality to ascertain the number of cows that can be depended on to supply the factory with milk. The area which may be drawn from will vary according to the kind of factory which it is desired to operate. A successful separator creamery will need at least 400 cows within a radius of four to five miles from the proposed factory.[1] Small cheese factories can be operated with less milk, and gathered-cream and butter factories generally cover a much larger territory than that mentioned. In all cases, however, the question of the number of cows contributing to the enterprise must be fully settled before further steps are taken, since this is a point upon which success will largely depend.

Methods of organization. The farmers should form their own organization, and not accept articles of agreement proposed by traveling agents. An agreement to supply milk from a stated number of cows should be signed by all expecting to join the association. When a sufficient number of cows has been pledged to insure the successful operation of a factory, the farmers agreeing to supply milk should meet and form an organization. This may be done according to either of the following plans which have been known to give good satisfaction.

Raising money for building and equipment.

First.—Each member will sign an agreement to pay on or before a given date for a certain number of shares in the company at.....dollars per share; or,

Second.—An elected board of directors may be authorized to borrow a sum of money not exceeding.....thousand dollars on their individual responsibility, and the sum of.....cents, (usually five cents) per hundred pounds of milk received at the factory shall be reserved for the payment of this borrowed money.

[1] Bull. 56, Wisconsin experiment station.

Constitution and by-laws of a co-operative association are drawn up and signed by the prospective members of the association when it has been determined to form such an association. It is impossible to include in an illustration all the articles and rules that may be found useful in each particular instance; the following suggestions in regard to some of the points to be included in the documents are given as a guide only. It may be found advisable to modify them in various ways to meet the needs of the organization to be formed.

After the constitution and by-laws have been drawn up and made plain to all the members of the association, they should be printed and copies distributed to all parties interested.

Constitution
or
Articles of Agreement of the.....Association.[1]

1. The undersigned, residents within the Counties of....., State of....., hereby agree to become members of the..... Co-operative Association, which is formed for the purpose of manufacturing butter or cheese from whole milk.

2. The regular meetings of the association shall be held annually on the.....day of the month of..... Special meetings may be called by the president, or on written request of one-third of the members of the association, provided three day's notice of such meeting is sent to all members.

Meetings of the board of directors may be called in the same way, either by the president or by any two members of the board of directors.

3. Ten members of the association, or three of the board of directors, shall constitute a quorum for the transaction of business.

4. The officers of the association shall include president, secretary, treasurer, one of whom is also elected manager, and these officers together with three other members of the associa-

[1] The following publications have been freely used in preparing this constitution and by-laws; Woll, Handbook f. Farmers and Dairymen: Minn. experiment station, bull. No. 35; Ontario Agricultural College, special bulletin, May 1897. See also Iowa exp. station, bull. No. 130

tion shall constitute the board of directors. Each of these six officers shall be elected at the annual meeting and hold office for one year, or until their successors have been elected and qualified. Any vacancies in the board of directors may be filled by the directors until the next annual meeting of the association.

5. The duties of the president shall be to preside at all meetings of the association, and perform the usual duties of such presiding officers. He shall sign all drafts and documents of any kind relating to the business of the association, and pay all money which comes into his possession by virtue of his office, to the treasurer, taking his receipt therefor. He shall call special meetings of the association when deemed necessary.

In the absence of the president, one of the board of directors shall temporarily fill the position.

6. The secretary shall attend all business meetings of the association and of the board of directors and shall keep a careful record of the minutes of the meetings. He shall also give notices of all meetings and all appointments on committees, etc. He shall sign all papers issued, conduct the correspondence and general business of the association, and keep a correct financial account between the association and its members. He shall have charge of all property of the association not otherwise disposed of, give bonds for the faithful performance of his duties, and receive such compensation for his services as the board of directors may determine.

7. The treasurer shall receive and give receipt for all money belonging to the association, and pay out the same upon orders signed by the president and the secretary. He shall give such bonds as the board of directors may require.

8. The board of directors shall audit the accounts of the association, invest its funds, appoint agents, and determine all compensations. They shall prescribe and enforce the rules and regulations of the factory. They shall cause to be kept a record of the weights and tests of the milk or cream received from each patron, the products sold, the running expenses, etc., and shall divide among the patrons the money due them each month. They shall also make some provision for the with-

drawal of any member from the association, and make a report in detail to the association at the annual meeting. Such report shall include the gross amount of milk handled during the year, the receipts from products sold, and all other receipts, the amounts paid for milk and for running expenses, and a complete statement of all other matters pertaining to the business of the association.

9. Among the rules and regulations to be enforced by the board of directors may be included some or all of the following:

a. Patrons shall furnish all the milk from the cows promised at organization of the association.

b. Only sweet and pure milk will be accepted at the factory, and any tainted or sour milk shall be refused.

c. The milk of each patron shall be tested at least three times a month.

d. Any patron proved to be guilty of watering, skimming or otherwise adulterating the milk sent to the factory, or by taking more than 80 pounds of skim milk or whey for every 100 pounds of whole milk delivered to the factory, shall be fined as agreed by the association.

e. A patron's premises may be inspected at any time by the board of directors, or their authorized agent, for the purpose of suggesting improvements in the methods of caring for the milk or the cows, in drainage and general cleanliness; or to secure samples of the milk of his cows for examination when it is deemed necessary.

10. Any changes or amendments to the by-laws or constitution of the association must be made in writing by the parties proposing the same, and posted prominently in a conspicuous place at the creamery, at least two weeks previous to their being acted upon. Such changes to be in force must be adopted by a two-thirds vote of the stockholders.

11. In voting at any annual or special meeting of the association, the members shall be entitled to one vote for each cow supplying the milk to the factory, or for each share of the stock owned by them, as agreed upon.

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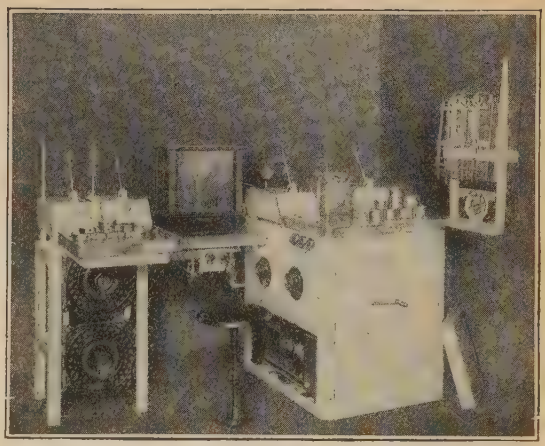

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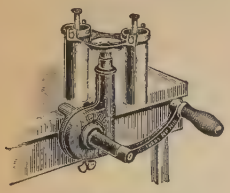

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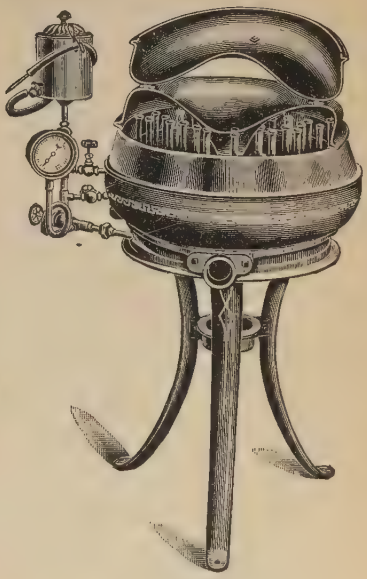

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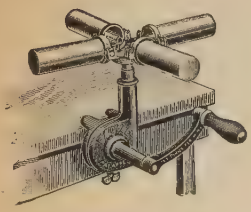

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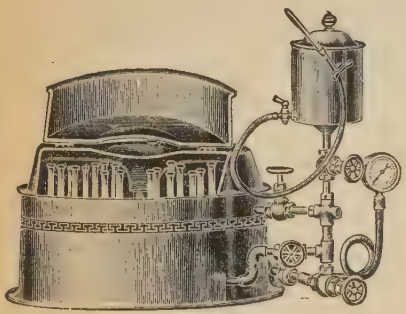

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